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Teaching Machines:
an annotated bibliography

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Teaching Machines: An Annotated Bibliography

Edward B. Fry • Glenn L. Bryan • Joseph W. Rigney

The bulk of the material in this bibliography was prepared for the Personnel and Training Branch, Psychological Sciences Division, Office of Naval Research, Contract Nonr-228(02), by Electronics Personnel Research Group, Department of Psychology, University of Southern California.

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Editor's Foreword

IT IS APPROPRIATE that the first special supplement of AV COMMUNICATION REVIEW direct its attention to that infant of audiovisual communication—the teaching machine. Regardless of the response evoked in each of us individually by the concept of "teaching by machine" we cannot deny the impact this device is making on modern education. We have a professional responsibility to learn all we can about it and to place it in proper perspective to other technological instruments of instruction.

Although we readily accept the principle of "self instruction" and might even be disposed to go along with the idea of certain kinds of "programmed learning," there is something in the term, "teaching machine," that repels many of us. It implies a condition of no compromise—a point of no return. To some it heralds the advent of dehumanized education. To others, however, the teaching machine signifies a major breakthrough toward the emancipation of the teacher to fill his proper instructional role. These educators believe that the full educational potential of the communication media may at last be realized through the teaching machine used in combination with television and other audiovisual media.

Thus recognizing the instructional importance of the teaching machine, the editors of AV COMMUNICATION REVIEW publish this comprehensive annotated bibliography as a baseline from which the interested reader can move. We wish to thank Drs. Fry, Bryan, and Rigney for making it available to us. We plan to keep the bibliography current with continuing annotations in the regular issues of this journal and to publish additional studies and theoretical articles related to automated teaching.

William H. Allen

I. Introduction

THIS BIBLIOGRAPHY is intended to show the scope of the relatively new field that is variously referred to as "teaching machines" or "automated instruction." It is our intention to save the interested student or research worker many hours of library research in going through journal after journal in hopes of finding an article on teaching machines. Such articles seem to have been published in a multitude of sources, some of which (such as military research reports) are unavailable to the average person.

If the reader is totally unfamiliar with the field, it is recommended that he first read at least one introductory article such as those written by F. Carpenter, Fry, or Lumsdaine. Most serious students will also want to read in the original at least the two basic articles in the field by Pressey (1950) and Skinner (1958). These basic articles and others by the same authors are the point of departure for most of the writing in the field.

For the purpose of this bibliography, we have defined teaching machines as devices which (1) present a unit of verbal or symbolic information visually, usually in question form; (2) provide the student with some means of responding to each unit; and (3) inform the student as to the correctness of each response. Also, most teaching machines do not allow the student to proceed until he has corrected a wrong response, and most of them require the subject matter to be organized in a step-by-step format called a program. We have chosen to err in the direction of leniency so far as this definition is concerned. Some training devices have been included in the bibliography that other specialists in the field might not classify as teaching machines. We have not included "language laboratory" references (except Morton, 1960).

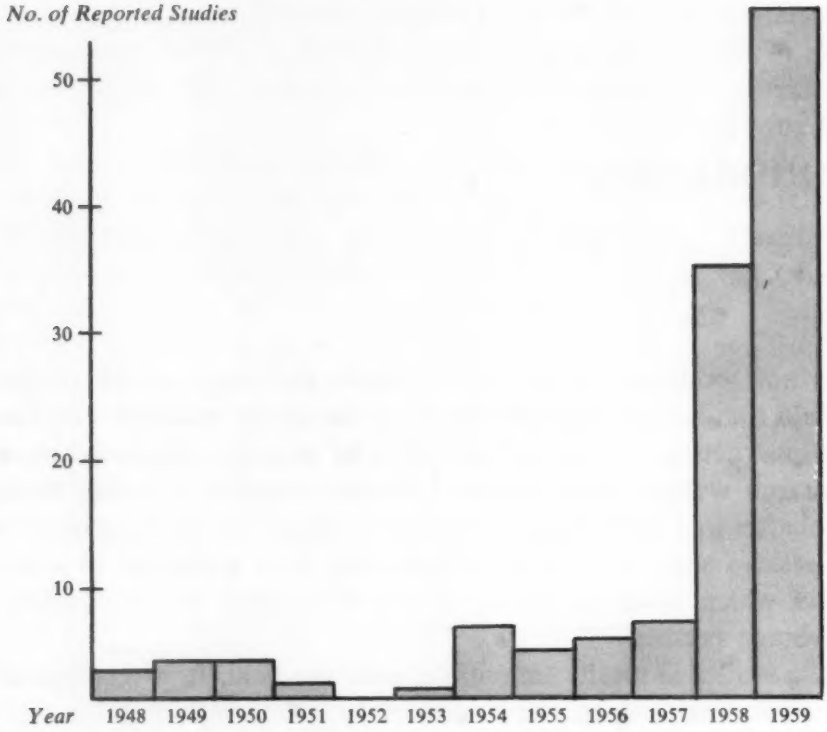

FIGURE I. *The frequency per year of teaching machine studies from 1948 to 1959. There were six references prior to 1948.*

There are some summarizing kinds of statements that can be made about these references. Figure I suggests that the life cycle of teaching machine research is entering its golden age. Whether this will be a substantial era or an ephemeral one is not yet clear. A rough categorization of the references in Figure II suggests that progress in a field is marked by discussion as well as by experimentation. This bibliography contains many discussions of theory and declarations of faith as well as articles bearing the stamp of the experimentalist.

Teaching machines take many forms. The machinery actually involved is usually simple: paper and pencil, or a primitive apparatus reflecting the psychologist's mechanical aptitude.

Lately, commercial interests have produced more sophisticated devices, and there is no doubt that these will be further refined if teaching machines prove marketable. Although all these devices are merely implementations of methods or principles, there may be some use for

a reasonably complete catalog of them. One of these is provided at the end of this introduction in terms of kinds of devices, and another at the end of the bibliography in terms of commercial machines that presumably are available.

The success or failure of teaching machines surely will depend upon the programs produced for them. It obviously is easier to build a gadget than it is to write a program for it. The known programs now in existence, and the current effort to produce more are summarized in Tables 1 and 2. Undoubtedly, these tables are incomplete, since more and more people are trying their hand at teaching machine programming every day.

Few would disagree that experimentation is the basis of significant progress in research. We have attempted to summarize in a very general way in Table 3 references reporting the result of experiments.

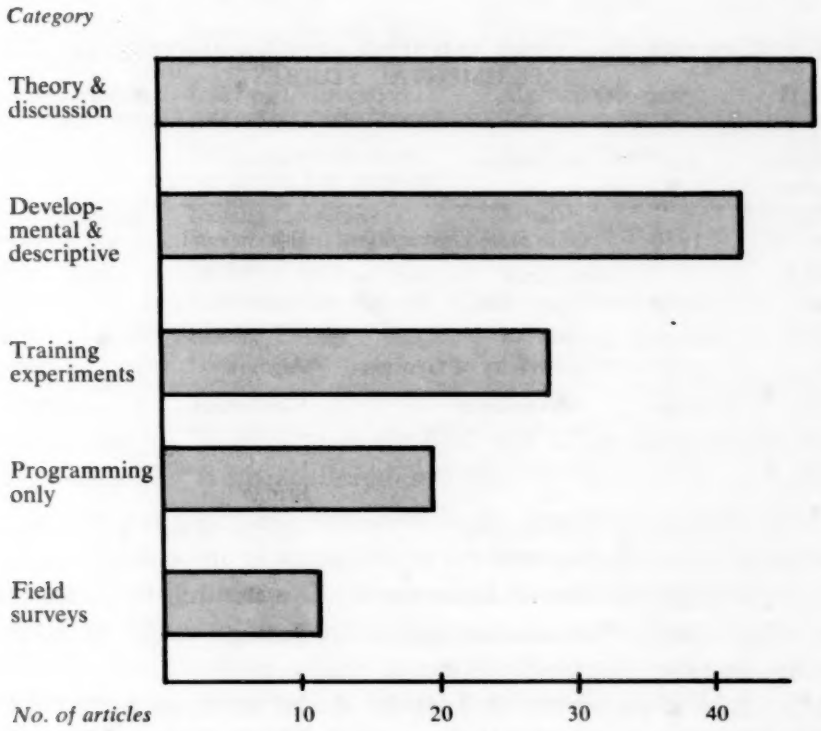

FIGURE 11. *Frequency of different categories of articles in the bibliography. (A few of the articles in the bibliography did not fit in these categories, and were omitted from this figure.)*

Although statistical results are not included there, many investigators did use tests of the significance of differences, and did base their conclusions on these tests.

This is not the only bibliography of teaching machine publications. Of the others, the most recent and complete was Darby's (1959). We have taken the liberty of copying a few of Darby's annotations (with acknowledgment) where he cited unpublished reports not available to us. In addition, we have included some material other than the conventional type of reference simply because it is of interest to us and probably will be to others.

The annotations are relatively brief, and are listed in alphabetical order. Although they amplify information in the titles, they are not intended to be adequate substitutes for reading the original articles. The bulk of the work of collecting references and of writing the annotations was done by Edward B. Fry. Any merits the bibliography may

TABLE 1—OLDER TEACHING MACHINE PROGRAMS DEVELOPED FOR EXPERIMENTAL STUDIES

Principal Investigator or Author	*Date*	*Institution*	*Subject*	*Level*
Pressey (et al)	1950	Ohio State University	Educational Psychology	College
Trainer-Tester	1954	Navy (SDC)	Electronics trouble shooting	Adult
Gilbert	1955	University of Georgia	Algebra	College (?)
Bryan	1958	University of Southern California	Electronics trouble shooting	Adult
Crowder	1958	Western Design	Number systems, Bridge	Adult
Evans	1958	University of Pittsburgh	Number bases	College
Meyer	1958	Harvard University	Arithmetic	Elementary
Porter	1958	Harvard University	Spelling	2nd & 6th grades
Schutz	1958	University of Arizona	Arithmetic	Elementary
Skinner (Holland)	1958	Harvard University	Psychology	College
Smith	1958	University of Michigan	Grammar	High school

TABLE 2—TEACHING MACHINE PROGRAM DEVELOPMENT IN PROGRESS IN EARLY 1960

Author or Investigator	*Institution*	*Subject*	*Level*
Barlow, John	Earlham College Richmond, Indiana	Russian, Spanish, Genetics, Statistics, Freshman English	College
Blyth, John	Hamilton Research Assoc. New Hartford, New York	Symbolic Logic	College
Evans, James (Homme & Glaser)	Teaching Machines, Inc. Pittsburgh	Statistics, Logic, Mathematics	College
Goodcharles, Charles	Hamilton College Clinton, New York	French, German, Mathematics, Philosophy, Psychology	College
Hively, Wells	Harvard University	Pre-reading	Pre-school
Keislar, Evan	University of California at Los Angeles	Science	Early elementary
Komoski, K. P.	Collegiate School New York 24	French, Arithmetic, Spelling	Elementary, High School
Lumsdaine, A. A.	American Institute of Research, Pittsburgh	TV lectures, SAGE operators	Adult
Mechner, Francis	Schering Corporation Bloomfield, New Jersey	Algebra, Geometry, Trigonometry	High school
Rigney & Fry	University of Southern California, Los Angeles	Boolean Algebra	Adult
Saltzman, Irving	Indiana University Bloomington, Indiana	Russian	College
Schuster, Don	University of Southern California, Los Angeles	Electronics trouble shooting	Adult
Van Atta, Loche	Oberlin College Oberlin, Ohio	Psychology, Genetics, Music Theory	College

have are due to his interest in the field and to his diligence in ferreting out information from scattered sources.

There is one technical term used in the teaching machine field which perhaps needs a bit of explanation for the new reader—"program" or its gerund "programming." When used by a teaching machine writer, a program refers to the curriculum material or subject matter that is placed in the machine which is usually carefully worked out and is composed of items on which the student can be successful a high percentage of the time. Confusion arises when authors in the field of electronic computers use "program" to refer to the detailed instructions given to the computer to enable it to perform a given task.—J.W.R.

TABLE 3—SUMMARY OF EXPERIMENTAL STUDIES

Investigator	*Number of Subjects*	*Length of Training*	*Criterion Test*	*Validation*	*Results*
Angell	81 pairs	Semester	Achievement	External	Punchboard group superior
Briggs	120	Semester	Achievement	External	Punchboard superior
Briggs	2 groups	13 min.	Achievement	Internal	Self-pacing vs. automatic pacing on subject matter trainer
Bryan	48	2 hours	Achievement	Internal	Three types of knowledge of results, all superior to control
Bryan	54	2 hours	Achievement	Internal	"Why wrong" group superior
Bryan	115	1 week	Achievement	Internal	Guidance superior to no-guidance; explanations superior to right-wrong
Cantor	690	10 weeks	Performance	Internal	Punchboard and trainer-tester superior to "equipment-only" group
Coulson	80	1 session	Achievement	Both	Studied step size, branching and response modes
Dowell	461	13 weeks	Performance & ratings	Both	Trainer-tested plus equipment best
Ferster	17	47 hours	None	None	Taught freshmen successfully with cardboard window device
Fry	150	1 session	Achievement	Internal	Constructed responses superior to multiple-choice using window folder
Hatch	2 squadrons	2 months	Achievement	External	Automatic Rater used incidentally increased job information
Holland	187	10 weeks	None	None	Taught psychology successfully with Skinner's disc machine

TABLE 3—SUMMARY OF EXPERIMENTAL STUDIES (Continued)

Investigator	*Number of Subjects*	*Length of Training*	*Criterion Test*	*Validation*	*Results*
Irion	80	20 min.	Training errors & time	Internal	Subject matter trainer O.K., quiz mode best
Jensen	24	Few weeks	Achievement (Final exam)	External	Punchboard group got better grades
Jones	748	Semester	Achievement (Course exam)	External	Punchboard superior to "regular class"
Keislar	14	3 days	Performance (Applied problem)	External	Film Rater can teach arithmetic concepts for elementary children
Little	Several classes	Semester	Achievement (Course exam)	External	Pressey's test machine superior to control
Mayer	?			Internal	Compared subject matter trainer and workbook
Meyer	26	? weeks	None yet	None (Demonstration)	Slider machine taught elementary arithmetic
Porter	25	Semester	Achievement	External	6th graders taught spelling by write-in machine
Porter	1 class	12 weeks	Achievement error score	External	2nd graders taught spelling; control exceeded experimental group
Pressey	225 plus groups	Several semesters	Achievement	External	Punchboard superior to control
Sevrin	2000 plus	30 min.	Achievement	Internal	Punchboard better, two choices as good as four
Stephens	1500 plus	1 day 3 trials	Achievement	Internal	Compared punchboard and multiple-choice drum tutor; meaningfulness; and item type

NOTE.—External means comparison with another method; internal means several conditions within the same method.

II. Summary of Devices

THIS SUMMARY is intended to show the range of devices referred to in the bibliography. It contains names and brief descriptions of some of the better known devices. It is not exhaustive. References (indicated by author's name and date of publication) at the end of each summary and in Table 4 point out, in each instance, only some of the places further information on that type of device can be found. When company names are used in the reference, the reader should refer to the final section of this report.

Automatic Rater

The Automatic Rater is a multiple-choice type of teaching machine. It was used during World War II by the Navy for incidental training and currently is being used by Keislar at UCLA for experiments in teaching arithmetic to children. The subject looks at a question on a small screen, then responds by pushing one of five buttons. He is given knowledge of results before the machine will move to the next item. Items are stored on a film loop. There is no variation in sequencing or mode. (Angell, 1948; Keislar, 1949a)

Auto-Score

The Auto-Score is a simple multiple-choice type of teaching machine in which items are printed on a plastic sheet. The student responds by touching the correct answer choice with an electric stylus. Knowledge of results is given and the student may not proceed to the next item until the correct response has been made. A counter tabulates errors. (Electric Boat Company)

Cardboard Mask

This device used by Ferster is perhaps the simplest teaching machine. It is merely a cardboard folder containing a mimeographed sheet which permits one line of text to be exposed as the sheet is moved upwards. When used in teaching German, the first line exposed is an English word; the student responds on a separate sheet of paper, then moves the paper within the mask up one line, thereby exposing the answer. He compares the answer he writes on the separate sheet with the answer in the machine. If this is correct, he marks an X on the margin of the drill paper within the machine. If incorrect, he marks a zero. He works through the drill until

he makes two correct responses to each line. (Ferster-Sapon, 1958)

Card Sort Device

The Card Sort Device was developed by Briggs and the Air Force. It is a multiple-choice type of teaching machine which presents cards, one at a time. The subject responds by pushing buttons on the front of the machine. Knowledge of results is given. No studies making use of this machine have been reported. A similar but simpler multiple-choice machine is the General Atronics Device. (Briggs, 1954)

Chemo Card

The Chemo Card is a specially prepared answer sheet for multiple-choice questions. The student responds by marking a spot with a special ink. If it is the wrong choice, the spot turns red; if it is the correct choice, the spot turns black. Students are instructed to continue answering each item until the correct choice is found. This device was developed by Peterson in the early 1930's and is still advocated by Pressey. (U. S. Patent 1884174.) (Peterson, 1930; Pressey, 1950)

Computers

An IBM 650 digital computer was used with a typewriter input-output as a teaching machine. Knowledge of results was given by having the typewriter keyboard freeze if an error was made. Branching was also used; students who responded correctly could elect to skip items. Currently, Coulson and Silberman are using a Bendix computer as a teaching machine. (Rath-Anderson-Brainard, 1958)

Film Analyzer

The Film Analyzer, or Classroom Communicator, as it is sometimes called, is not a true teaching machine; rather, it is a group feedback device. Each seat in the classroom has a set of buttons or a resistance valve. Questions or materials to be analyzed are presented to the group by lecture or film or other visual device and the student responses are shown to the instructor individually and collectively. Knowledge of results may be provided. (Twyford, 1956)

Micro-Film Reader Device (Western Design Tutor)

This device is essentially a mechanized scrambled book in which pages of the book are put on film. The device then provides random access to any frame and presents it on a viewing screen before the individual operator. It also shows motion picture sequences. (Western Design Company)

Multi-Purpose Self Trainer

This is a tab answer sheet developed by Nelson. The student responds to mimeographed multiple-choice questions by pulling an appropriate tab off the answer sheet. Beneath the tab is indicated whether or not the response is correct. An alternate form of the answer card gives the ranking of answers, indicating whether it was the best possible choice, the next best possible choice, and so on. (Management Research Associates)

Omnideck

Omnideck is simply a set of data-processing cards (IBM, Rand, etc.) which contain a question on one side and the answer on the other. They are used as items are in a programmed text. They seem particularly well suited to program development and research work. (Teaching Machines, Inc.)

Optimal Sequence Trainer (OST)

This is a small electronic device designed to give knowledge of results and guidance during long, multi-step, trouble-shooting problems in electronics. The student queries the machine by setting in a code number from 1 to 1000 for a step about to be taken. If the step is the optimal one, a green light is given. If the student hesitates more than seven minutes between steps, the device tells him how to proceed. Problem material is presented in written form on the machine and diagrammatically in separate mimeographed books. (Bryan, 1959)

Polymath

This device, designed at Bell Laboratories, provides for several different types of responses. Alphabetic or numeric responses may be made by moving sliders. Graphic responses, such as the tracing of a route on a map, may be made by moving a stylus arm over a surface. An unseen printed circuit on the back of this surface can provide continuous knowledge of results. (Lumsdaine, 1959)

Pressey's Multiple-Choice Machine

The first regular teaching machine was Pressey's, as described in a 1926 article. Questions were presented on a mimeographed sheet and the student responded by pushing a button on the machine. The machine was keyed to the questions and the student could not proceed until he had made a correct response. An error count was kept by the machine. Pushing a shift lever changed the machine to a self-tester permitting a new question to turn up whether the answer was correct or not, the counter in the meantime counting rights. Tangible rewards such as candy life-savers were automatically given for high scores. A modification of this device for drill repeated only those questions on which a mistake had been made. Another modification was marketed by the Welch Apparatus Company in 1929. (Pressey, 1926, 1927)

Programmed Text

This device, developed by Homme, Glaser and Evans, is a unique form of textbook. The top third, or panel, on a page presents a question. The student responds to the question subjectively and then turns the page to learn the next question on the top panel, continuing as before. After the student has worked through all of the top panels, he returns to the front of the book and works through the middle panel; then the lower panel. (Homme, 1958; Glaser, 1959; Teaching Machines, Inc.; Harcourt Brace and Company)

Pull-Tab

The Pull-Tab was used by Bryan and Rigney for giving knowledge of results to multiple-choice items. A paper tab is pulled opposite an answer. Beneath the tab there may be a simple "yes" or "no" or a more detailed description of why the answer was correct or incorrect. A related device is the Multiple-Purpose Self Trainer, in which a pulled tab indicates rank of answer. (Bryan, 1956; Management Research Associates)

Punchboard

The Punchboard was developed by Pressey at Ohio State. It is a small board, about the size of a man's hand, which contains rows of holes. Multiple-choice questions are presented on a separate mimeographed sheet, and the students respond to each question by pushing a hole in the appropriate row. If his choice is correct, the pencil goes

deep into the punchboard; if he is wrong, the pencil does not go so deep. Each punch, correct or incorrect, makes a hole in the paper, which can be preserved. Numerous studies have been done at Ohio State by Pressey and his graduate students, using this punchboard. Navy Special Devices Center has developed a very similar punchboard and has sent some to the fleet for utilization. (Pressey, 1950; U. S. Navy; Science Research Associates)

SAKI Key Punch Trainer

This device uses a small computer to train key punch, adding machine, or typewriting skills. The student types on the keyboard from a set copy. Each digit that he should be typing is lighted. If he pushes the correct button on the keyboard, the machine progresses; if not, it stops. (Rheem Manufacturing Company, now known as Rheem Califone Corporation, DIDAK 1001)

Scoring Machine

The scoring machine is not a true teaching machine. It is simply a rapid automatic scoring device. The students take a quiz in class; as they finish, they present their papers to the instructor who places them in the scoring machine. Scoring is done immediately, and an error count taken by item. At the conclusion of the class, the instructor discusses the items which were most frequently missed. (Pressey, 1932)

Scrambled Book

The Scrambled Book presents a problem situation on the first page with several multiple-choice answers at the bottom. The student responds to the question by selecting an answer at the bottom, which gives a page number. He then turns to this page and is told whether or not his selection is correct and why. This device provides branching, which means that students making incorrect responses are given remedial help or are led to repeat a certain section of the main program. (Crowder, 1958)

Simple Write-In Machine

This device, used mainly by Porter, is a write-in type of teaching machine. It merely controls the exposure of mimeographed sheets of paper so that only one line at a time can be shown. The student writes directly on the exposed line then moves a lever which exposes the answer and the next line. He can still see his response under a sheet of glass; he indicates on the answer line whether he was correct or incorrect. The device is hand-fed but satisfactorily prevents cheating, which could be accomplished by looking ahead. It has been used by Porter to teach spelling to second- and sixth-graders, and by Schutz in Arizona for programming problems. Similar simple write-in machines are Rheem's DIDAK 501, the Foringer Machine and the Bell device. (Porter, 1958)

Skinner's Disc Machine

This is a write-in type of teaching machine. Questions are presented in a window, and the student responds by writing on a paper tape inside the machine. Upon completion of his answer, the student activates a lever which exposes the answer and covers his written response. He compares his written response with the answer in the machine and, if correct, activates the lever in another manner which causes the item not to appear again. This machine has been used mainly to teach psychology to college students. (Edwards, 1956; Skinner, 1958)

Skinner's Multiple-Choice Machine

This is a simple multiple-choice machine used in presenting non-verbal material to primary children. Information is presented in a small window, and the child responds by pushing one of several windows which have matching items. Knowledge of results is given. (Also see Rheem's DIDAK 101 and 601.) (Edwards, 1956; Skinner, 1958)

Skinner's Slider-Arithmetic Machine

This device causes the student to respond by moving a slider to construct his answer. Sliders can give any number or any letter of the alphabet. Questions are presented on printed tape in a small window. This machine has been used mostly to teach arithmetic to primary children, although it could also be used for teaching spelling. (Edwards, 1956; Meyer, 1958; Skinner, 1958)

Subject Matter Trainer

This is a large multiple-choice machine which presents questions in a small window. The student responds by pushing one of 20 buttons, each opposite a possible answer. The machine may be set for various modes of operation, such as telling the student the answer after one choice, or telling him only after he has made the correct choice. (Briggs, 1958)

Tab Item Test

The Tab Item Test is used more for trouble-shooting and similar problem-solving situations than as a teaching machine. Multi-step problems are presented. The student works the problem by pulling tabs which simulate making a response. The answer from the first response directs him in making a second response. Usually the goal is to work through to the final correct solution of the problem with a minimum number of responses. (Cross, 1955; Glaser, 1954)

Trainer-Tester

The Trainer-Tester usually presents a multi-stage problem on a printed sheet of paper. Responses are made by erasing a silver overlay revealing the answer beneath. The results of one step frequently give the student knowledge so that he can proceed to the next. This device is usually used in conjunction with diagrams in trouble-shooting problems. (Renner, 1958)

Video-Sonics

This is a total audio and visual, sequentially programmed device for production training and maintaining production efficiency. The worker sees a graphic demonstration on an individual screen and hears oral instructions over earphones. The Hughes Aircraft device uses a 35mm-slide visual device while the Maccoby and Sheffield device uses a motion picture projector with a five-minute film loop. (Klass, 1960; Lumsdaine, 1959)

Wycoff Film Tutor

This device presents constructed-type items in a special machine by means of an 8mm projector. The student responds by constructing his own answer on a special set of five keys. Various combinations of the keys make up the alphabet and 10 digits. (Teaching Machines, Inc.)

TABLE 4—LIST OF DEVICES MENTIONED IN THE BIBLIOGRAPHY WITH A TABULATION OF THE NUMBER OF TIMES THEY WERE PROMINENTLY MENTIONED

Device	*No.*	*Device*	*No.*
Automatic Rater (Navy and Keislar)	3	Optimal Sequence Trainer (Bryan)	1
Auto-Score (Electric Boat)	1	Polymath (Rothkopf-Lumsdaine)	1
Cardboard Mask (Ferster)	3	Programmed Text (Glaser, Homme, Evans)	3
Chemo Card (Pressey-Peterson)	1	Pull-Tab (Bryan)	2
Computers (Rath)	6	Punchboard (Pressey)	10
Disc Machine (Skinner)	4	SAKI Key Punch Trainer (Rheem)	2
Film Analyzer (Twyford)	2	Scoring Machine (Pressey)	2
Hamilton College Device (Homme's Notes)	1	Scrambled Books (Crowder)	3
Micro-Film Reader (Western Design Tutor)	2	Simple Write-In Machine (Porter)	6
Multiple-Choice Machine (Pressey, Skinner, Briggs)	11	Slider-Arithmetic Machine (Skinner)	4
Multi-Purpose Self Trainer (Nelson)	1	Tab Item Test (Glaser)	2
Omnideck (Teaching Machines, Inc.)	1	Trainer-Tester (Dowell)	4
		Wycoff Film Tutor (Teaching Machines, Inc.)	1

III. Annotated Bibliography

Angell, G. W., and Troyer, M. E. "A New Self-Scoring Device for Improving Instruction." *School and Society* 67:84-85, 1948.*

This article describes the use of punchboards with chemistry students and gives a basic introduction to some older automatic teaching devices.

The article has one of the few references to an older teaching machine called the Automatic Rater which was used by the Navy during World War II. This device gave immediate knowledge of results to multiple-choice questions projected on an individual viewing plate. The Rater weighed about 175 pounds, stood 48 inches tall, and was 18 inches wide and 26 inches deep.

Angell and Troyer describe the use of a punchboard which was accompanied by changeable answer sheets and mimeographed multiple-choice questions. (See Pressey's 1950 article in the *Journal of Psychology* for a more adequate description of punchboards.) While the study actually antedates Pressey's major study published in 1950, it acknowledges the development of the punchboard technique by Pressey. The interesting thing about this study is that it was used primarily by chemistry instructors who had no bias for or against automatic teaching devices. That the use of the machine was a success is shown by the following statement: "Data from both studies showed that learning is significantly enhanced by immediate knowledge of results through the punchboard technique." (p. 85)

Angell, G. W. "Effect of Immediate Knowledge of Quiz Results on Final Examination Scores in Freshman Chemistry." *Journal of Educational Research* 42: 391-94, 1949.

Here an experimental group used punchboards on three hour-long quizzes. Eighty-one matched pairs were used. On the final examination, the experimental group did significantly better.

A variety of types of problems were used. The experimental group did slightly better on application problems than on factual problems, but the difference was not significant. While the punchboard group was slightly more nervous, this did not seem to affect the final scores. Some students felt that the punchboards were more cumbersome, yet they preferred them and considered them an opportunity to further learning. It took the instructors 90 minutes to prepare 100 punchboards for a quiz. The study covered several sec-

* The asterisk following the reference means that the article appears in Lumsdaine, A. A. and Glaser, Robert, editors. *Teaching Machines and Programmed Learning: A Source Book*. Washington, D. C.: Department of Audiovisual Instruction, National Education Association, 1960 (in press).

tions of freshman chemistry students and in each section, whether experimental or control, quiz papers were returned and correct answers discussed at the next regular recitation period. Hence all students received relatively efficient feedback in terms of normal instruction techniques. That the punchboard group was significantly better is interesting in light of the very small use of punchboards (only during three one-hour quizzes). The criterion of improvement was the final score.

Barlow, John. *Earlham College Student Self-Instructional Project, First Quarterly Report.* Unpublished report submitted to the U. S. Office of Education, Earlham College, Richmond, Indiana, 1959.*

Sparked by a lecture from B. F. Skinner, the college started a large-scale project of program development assisted by a $140,542 grant from the U. S. Office of Education. They intend to raise an additional $105,000 from non-federal sources. A progress report at the end of 1959 states that materials have been and are being programmed for the following courses: genetics, freshman English, statistics, introduction to music, Old Testament, and elementary Russian. Some experimental research is being done involving teaching effectiveness of the genetics program and the Skinner-Holland psychology program. John Gulpin is experimenting with variables in presentation and motivation.

Barlow, John. "Project Tutor." *Psychological Reports,* Vol. 6, No. 1, February 1960.

The article includes an introductory discussion of the benefits of teaching machines with particular reference to Skinnerian principles. The unique half of the article describes a matrix method for developing questions to be used in program writing which was used by Lloyd Homme.

Beck, Jacob. "On Some Methods of Programming." In *Automatic Teaching: The State of the Art,* edited by Eugene Galanter. New York: John Wiley & Sons, 1959.

Beck states that programmers should maximize the correct responses, a view which is in line with Skinner's thinking about programming. Beck approves of the use of hints and prompts to help the student arrive at the correct answer. Hints and prompts, he believes, could be augmented by such devices as copying, analogy, and use of rules. He contrasts this with a pure deductive method which uses no hints.

Beck analyzes the teaching process as a situation which uses discrete responses, rules to guide responses, and differential reinforcement. Usually textbooks and lectures are examples of uncontrolled devices, by which Beck means that the student, in an unstructured situation, may focus on the wrong stimuli. He explains that while the student is focusing on the wrong stimuli, reinforcement *could* take place, but it would be accidental. This seems to be in line with Skinner's idea of "superstitious behavior."

Besnard, Guy G.; Briggs, Leslie J.; and Walker, Elbert S. *The Improved Subject Matter Trainer.* Technical Memorandum, Armament Systems Personnel Research Laboratory, Lowry Air Force Base, Colorado, April 1955.

This is a report of the development of the Subject Matter Trainer, an electromechanical device used for teaching and testing general verbal subject matter.

The machine handles 20 questions with 20 possible answers under six modes of operation. The device is used in training research and testing. A more detailed description of this device is contained in Briggs' 1958 article.

Briggs, Leslie J. "The Development and Appraisal of Special Procedures for Superior Students and an Analysis of the Effects of 'Knowledge of Results'." *Abstracts of Doctoral Dissertations*, No. 58, The Ohio State University Press, 1949.

Briggs uses Pressey's punchboards in an attempt to give accelerated training to superior college students. Approximately 300 students are enrolled each quarter in a beginning course in educational psychology. From this number about 30 are selected each of the four quarters to participate in accelerated seminars. The selection of students is made on the basis of high motivation for superior work. Older students, especially veterans, are given preference if they meet the other requirements. These students do not attend the regular class but attend only one two-hour meeting each week. During the class period they are given tests of a factual and applicational nature, using the punchboard. In addition, laboratory demonstrations and discussions of supplementary materials are employed. During each quarter the accelerated students (the experimental group) take the same mid-term and final examinations as the students in the regular courses. Each student in the accelerated seminar is paired on the basis of intelligence and other factors with a student in the regular course. Briggs reports that 65 percent of the accelerated students earned A or B grades, while only 55 percent of the controls earned such grades. Test scores are subjected to a three-component analysis of variance. The superiority of the accelerates over the controls is significant at the 5 percent level.

In a separate section of this study Briggs attempted to select very superior students and give them even less controls, less class time, less discussion, etc. When these students were compared with matched pairs in regular classes, a *t* test revealed no significant differences, but much time was saved.

In another part of the study, Briggs attempted to verify the effectiveness of knowledge of results. He found that the punchboard used in the regular manner, that is, working each item until a correct answer is found, was superior to a simpler type of knowledge of results in which a student was allowed only one try at each item, and was then informed of the correctness or incorrectness of that one try. Both modes of operation which used knowledge of results were superior to the regular test procedure in which no knowledge of results was given. In each case, *t* tests were significant at the 1 percent level.

Briggs, Leslie J. "Two Self-Instructional Devices." *Psychological Reports* 4:671-76, 1958.*

Briggs describes his Subject Matter Trainer in some detail, with particular reference to modes of operation. He also describes briefly a "card-sort" device.

The Subject Matter Trainer is a machine so large that the student must stand up to operate it. On the viewing surface 20 response items are continuously present. Adjacent to each response item is a small button which the student presses to indicate his selection. The questions appear one at a time in

a small window to the side. After presentation of a question, the student responds by pressing a button. If he answers correctly, he is given the green light and the next question is presented.

The Subject Matter Trainer can be operated in several modes, as follows:

The coaching mode. In this mode, the student merely reads the item and presses a special button which shows a green light next to the correct answer. The student then presses the correct answer button and is permitted to go on to the next question. Notice that there is no quizzing involved. The student is simply told the correct answer, is forced to respond, and the machine puts on the next item. In a study to be reported later (in collaboration with Irion) it was found that the coaching mode was the most efficient single mode of operation. Briggs and Irion reported surprise at this fact, yet it seems to be in line with other non-teaching machine studies in the field of educational psychology.

The single error permitted mode. In this mode, the student is allowed to make only one choice. If his response is correct, a green light is shown; however, if the response is wrong a buzzer sounds and *then* he is shown a green light glowing next to the correct answer. Thus, only one response is made and no more than one error can be made before the student is shown the correct answer.

The practice mode. In this mode, a buzzer is sounded after each error is made, but the subject can make any number of errors. When finally the correct response is made a green light is shown and the student can go on to the next item.

The single try mode. Under this mode of operation, the student is given only one try. If he is correct, a green light appears; if his answer is incorrect, the buzzer sounds. The student is not permitted to make any more attempts, hence he knows whether his one response is right or wrong. However, if wrong, he must stop working, and is not permitted to know which of the other 19 remaining choices is the correct answer.

The paced-practice mode. In this mode, an electrical timer is connected to control the exposure time of the stimulus item. The machine can then be operated under any of the above described modes.

The test mode. The final method of operating the machine makes use of the machine merely as an automatic quizzer. The subject makes one attempt to answer each item, but no feedback or knowledge of results is given. The machine automatically tallies the number of right and wrong responses.

The Subject Matter Trainer can be made to handle more difficult problems by placing circuits or additional information on a fixed panel which the student can view at any time.

Concerning the effectiveness of the Subject Matter Trainer, Briggs states: "Use of the device by an experimental group resulted in maintenance criterion scores which were significantly superior to scores earned by a regularly trained group." This was in reference to a study made by Briggs and Besnard for the Air Force and reported in *Symposium on Air Force Human Engineering Personnel and Training Research* (Washington, D. C.: National Academy of Science, National Research Council, Publication 455, 1956).

Briggs also describes the Card-Sort Device, which is similar to the Subject Matter Trainer in some modes of operation. Physically, the Card-Sort Device is much smaller, and handles data programmed on small cards. Each card is presented in a picture window, the responses being made by pushing one of four buttons; hence the machine is used primarily with multiple-choice problems. The subject is given immediate knowledge of results. The device separates correctly-answered from incorrectly-answered cards and on succeeding trials the subject is presented only those items which are answered incorrectly on a previous try. A maximum of 100 cards can be inserted into the device.

Briggs, Leslie J. "Teaching Machines for Training of Military Personnel in Maintenance of Electronic Equipment." In *Automatic Teaching: The State of the Art*, edited by Eugene Galanter. New York: John Wiley & Sons, 1959.

Briggs discusses, with illustrations, two machines treated earlier, namely the Subject Matter Trainer and the Card-Sort Device (see Briggs, 1958). He also mentions a "Complex Procedural Trainer" described as being in the planning stage. There was some suggestion that Hughes Aircraft was interested in producing this device. As a mock-up, it contains a rather complex electronic circuit, probably some type of automatic firing device similar to that used in aircraft. The mock-up is used in combination with a computer type of device. As the trainee works on a mock-up in a trouble-shooting type of situation, the computer or mock-up freezes if an error is made.

Briggs also mentions another machine in the planning stage which he calls the Trouble-Shooting Trainer. This device is similar to the Complex Procedural Trainer, except that logic circuits are added to determine if each check by the trainee is "reasonable," considering all of the possible alternatives at that given choice point.

Briggs, Leslie J. *Teaching Machines: History and Possible Applications to Air Force Education and Training Programs.* Paper prepared for presentation at a Symposium on Education and Training Media, Washington, D. C., August 18 and 19, 1959, under the sponsorship of the U. S. Air Force, National Research Council.

This 51-page report traces the development of teaching machines, beginning with Pressey's early machine and ending with Skinner's disc devices and such "paper-teaching" machines as Crowder's book.

Briggs feels that the use of teaching machines is justified whenever it is shown to be superior to regular training methods. These training devices should also be used when there is a shortage of skilled instructors. Briggs identifies a number of factors which, he feels, make teaching machines more effective than normal instructor-student interchanges. They are: (1) an expert program writer can reach a number of students, (2) misconceptions held by minimally qualified instructors will not be passed on to students, (3) errors are immediately corrected and do not lead to further errors in the problem sequence, (4) the student works at his own rate, (5) slow students are required to master the material and fast students can save time, (6) slow students are not embarrassed by their lower rate of learning, (7) fast students can do extra assignments, participate in discussion groups, and perform laboratory or field exercises to develop further

skills, (8) the need for examination is greatly reduced, (9) the experiencing of success augments motivation, (10) good instructors may use their time to better advantage than performing rote drill.

Briggs states that Pressey's and Skinner's devices present essentially "fixed programs." In the future, he believes, machines will retain some of their present characteristics, but may first run a test program to find out what the student already knows on the topic, and then select one of several basic programs available on the same lesson. The machine may be used to adjust the program on a continuous basis as a function of the responses of the student. This type of "branching" is already used to some extent in Crowder's Scrambled Books, the Tab Test, and the Microfilm Device. In conclusion, Briggs anticipates the possible need for more than one kind of machine because of the probability that there may be more than one kind of learning. Individual differences among students may justify other kinds of flexibility; also, in some subjects, at least, there is a need to wean the student from initial training stages.

A section is devoted to further information on the Subject Matter Trainer and a report of two informal try-outs of this trainer conducted at Chanute Air Force Base and at Francis E. Warren Air Force Base by training supervisory personnel. Lack of suitable measures of performance proficiency led to inconclusive results when comparing experimental and control groups. However, student and instructor responses to the device were favorable. A negative recommendation concerning routine use of the device was based in part on a shortage of personnel to handle maintenance.

Briggs, Leslie J. "Teaching Machines, Education, and Job Skills." *Psychological Reports*, Vol. 5, No. 2, 1959.

This article is a one-page overview of the teaching machine field. Opening with Simon Ramo's belief that automated instruction promises to revolutionize our methods of teaching, Briggs briefly surveys the work of Pressey and Skinner, and concludes with the idea that machines may pre-test students and proceed to optimum automatic instructional programs.

Briggs, Leslie J. *Applied Research Problems.* Abstracts from Symposium on Automated Teaching, Western Psychological Association Annual Meeting, San Diego, April 1959.

Briggs outlines three stages in the development of planning training: (a) identification of verbal learning to be accomplished, (b) programming of this information on the teaching machines, and (c) development of complex simulators so that verbal information can be transferred to perceptual and motor performance on actual job operations. Briggs believes that our present knowledge of learning and so-called "pure examples" of learning (such as rote memorization, concept formation, and conditioned responses) do not provide a realistic framework for the development of needed complex skills trainers (that is, learning is often multi-factoral).

Briggs, Leslie J. *Problems in Simulation and Programming in the Design of Complex Skill Trainers.* Paper presented in Symposium on Research Issues in the Study of Human Learning Raised by Developments in Automated Teaching, American Psychological Association Annual Convention, Cincinnati, September 1959.*

In this paper Briggs is concerned with the application of learning research to maintenance training. There has been

research in the area of purely verbal or symbolic learning (conceptual learning); at the same time, unrelated research has been done in the area in purely motor learning. The two must be combined, he feels. In a maintenance training situation both of these types of learning take place. The student must first use a symbolic-conceptual type of problem solving to locate the difficulty, then go through certain motor acts to correct it. Hence, maintenance is a combination of symbolic problem solving and motor skill, and there has been little research done in the combination of these areas.

Briggs, Leslie J.; Plashinski, D.; and Jones, D. L. *Self-Pacing Versus Automatic Pacing of Practice on the Subject Matter Trainer.* Unpublished draft, circa 1955; cited in Darby 1959.

"The purpose . . . was to determine whether, for a specified problem and a specified mode of operation, subjects would learn more in a given total practice period by pacing their own practice or by receiving material automatically paced at arbitrary selected intervals.

"Two groups of subjects were given approximately 13 minutes of practice on a 20-item paired-associate problem. One group was allowed to pace the presentation of the stimuli; pacing was automatic for the other group. Both groups were given a test trial.

"No difference between effectiveness of the two methods of pacing was demonstrated." (from Darby)

Bryan, Glenn L., and Rigney, Joseph W. *An Evaluation of a Method for Shipboard Training in Operations Knowledge.* Technical Report No. 18, Electronics Personnel Research Group, University of Southern California, September 1956.

The report represents the results of a study performed to evaluate a possible shipboard training method. The standard multiple-choice item was modified to convert it to a training device. This was accomplished by developing short verbal explanations to accompany each alternative for each item. These explanations were concealed under paper tabs so constructed that a tab opposite each alternative could be pulled off when that alternative was selected as the correct answer for the item. This method of presentation is sometimes referred to as the "pull tab" device. In this fashion, it was possible to relate the subject matter of the item to the trainee's information, and to explain to him why the alternative he selected was the correct or incorrect answer.

Forty-eight senior NROTC students were randomly assigned to three groups. One group served as a control and answered the items in the usual testing way. During the training session they made exactly one response to each of 150 items. A second group was given immediate knowledge of the correctness of their responses by a "right" or "wrong" and was required to continue selecting answers to each question until they located the keyed answer. The third group was the same as the second with the important exception that explanations of why each item alternative was right or wrong were printed under pull-off tabs opposite the alternatives.

All groups were tested on a multiple-choice criterion test one week after the training session. Comparison of the criterion means indicated that explanation of choices was significantly more effective than the other modification, and that a self-trainer incorporating this training method also could be scored and used as a diagnostic test.

Bryan, Glenn L.; Rigney, Joseph W.; and Van Horn, Charles. *An Evaluation of Three Types of Information for Supplementing Knowledge of Results in a Training Technique.* Technical Report No. 19, Electronics Personnel Research Group, University of Southern California, April 1957.

This study sought to determine the relative effectiveness of three different kinds of explanations when employed in the multiple-choice trainer format. Report No. 18 by the same senior authors had indicated that explanations generally were effective in this training situation.

A selection of multiple-choice items was made from among those employed in the original study. Three different kinds of explanations were written to rationalize the scoring key used for each item alternative. The kinds of explanations employed differed as follows:

Type 1. Explanations which gave the trainee the correct definition or description of the chosen alternative.

Type 2. Explanations which indicated the *principal reason* why the chosen alternative was keyed as correct or incorrect.

Type 3. Explanations which pointed out the probable *operational consequences* of the course of action represented by the alternative.

Forty-eight senior NROTC students from Stanford University served as experimental subjects. Each student participated in a one-hour training session which was followed one week later with a criterion test. The primary experimental data consisted of the differences between each man's score before and after receiving the training.

Analysis of the data revealed that significant learning occurred as a result of the one-hour training session with all of the three types of explanations employed. No one type of explanation was found to be superior.

Bryan, Glenn L., and Schuster, Donald H. *An Experimental Comparison of Trouble-Shooting Training Techniques.* Technical Report No. 30, Electronics Personnel Research Group, University of Southern California, December 1959.

The training effectiveness of guidance and explanations were investigated using 115 Navy electronics technician students at Treasure Island, California. The students were assigned randomly to five different training groups, defined below. Each group was trained to apply trouble-shooting principles in locating defects in a malfunctioning DAS-3 Loran, an electronic navigational aid. In the experiment, the Loran was simulated by means of schematic diagrams, illustrations, and circuit status information. The independent variables were the degree of guidance and the amount of explanation given. The dependent variable was the score obtained on an objective trouble-shooting test.

Each student participated in the experiment for five days. The first was devoted to standardized formal training consisting of tape and slide lectures, question periods, and familiarization with training materials. This was followed by three days of training, and one day for the criterion test.

Group 1 used the same trouble-shooting training materials as did the other groups, but were given no assistance. They worked through as many of the 60 training problems as they could in three days. Each problem was introduced by a sketch of the Loran front panel showing the symptoms of a malfunction. The trainee sought to locate

the defective part by consulting the results of various circuit tests, for example, voltages and waveforms. Provision was made to "test" a part if it was suspected of being defective. The problem was concluded when the defective part was located, and the man went on to the next training problem.

Group 2 followed the same procedure as Group 1 but in addition it employed a specially constructed device called the Optimal Sequence Trainer (OST) which provided immediate knowledge of results and delayed cuing. Before making a circuit check the student set a code number into the OST. If that number corresponded to a programmed sequence of trouble-shooting steps a green light showed. The student was permitted to look up the results of the check only if the machine had given him a green light. If for any reason the student delayed for more than seven minutes, the OST would tell him which step to take.

Group 3 followed the same procedures as the others except that the guidance was controlled by a Scrambled Clues List. The student worked through the problem by following a list of steps specified by a trouble-shooting expert. These were incorporated in a scrambled list so that the trainee had to follow each step in proper sequence.

Group 4 was treated as Group 2 and in addition was provided with written explanations to be opened after each "green-light" check. The explanations sought to justify the selection of that step in the optimal sequence.

Group 5 was similar to Group 3 except that members were given explanations to accompany each of the steps in the optimal sequence.

Results of the criterion test showed that the two guidance groups were significantly superior to the no-guidance group (.05 level) for the total number of items correct and the total number of tabs pulled. The criterion test was a modified Pull-Tab Test (see Bryan, 1956). No statistically significant differences among guidance groups occurred in terms of weighted errors or elapsed time.

The groups receiving explanations were significantly superior (.01) to the others in terms of the total number of items correct, number of tabs pulled, and weighted errors. Again, elapsed time differences were insignificant.

Buitenkand, Nathan. *Methods of Instruction in Component Location for Trouble-Shooting in Complicated Equipment and Means for Testing Accuracy of Answers.* U. S. Patent No. 2,764,821. Filed August 25, 1953 (assigned to Van Valkenburgh, Nooger, and Neville, Inc., New York), patented October 2, 1956.

This is the basic U. S. Patent for the Trainer-Tester described in Section IV under the heading Van Valkenburgh, Nooger, and Neville, "Trouble-Shooting Trainer-Tester." Reference is also made to the same device under the bibliographical heading, Renner, Inc., *Inexpensive Missile Training—A New Approach,* a paper presented at the U. S. Navy Guided Missile Training Symposium, Naval Ordnance Laboratory, Whiteoak, Maryland, March 1958.

Cantor, J. H., and Brown, J. S. *An Evaluation of the Trainer-Tester and Punchboard-Tutor as Electronics Trouble-Shooting Training Aids.* Project 20-F-14-3. Report NAVTRADEVCEN 1257-2-1. Special Devices Center, Port Washington, New York, October 1956.

In this experiment conducted at Great Lakes Naval Training Station, three

groups were used. The first was the T-T, or Trainer-Tester group; the second was the P-T, or Punchboard-Tutor group; the third was the E-group, or Equipment-Only group. The Trainer-Tester was a large sheet with silver overlay printed over answers to trouble-shooting problems. (This device was developed by Van Valkenburgh, Nooger and Neville, Inc., its early development having been done by Special Devices Center.) The Punchboard-Tutor was essentially the same device as that developed by Pressey and reported in his 1950 study. The Equipment-Only group used the Navy's traditional method of training in electronics using actual mock-ups of electronics equipment. All three groups were enrolled in regular equipment trouble-shooting courses. In general, the Trainer-Tester and Punchboard-Tutor groups were superior to the Equipment-Only group. The report stated that the T-T and P-T groups were definitely superior in intellectual aspects while the E-group was superior in equipment usage. Other criteria which showed the superiority of T-T and P-T groups were examinations, grades in course work, and lab grades. The report concluded that laboratory exercises can be replaced in part by training aids.

Estimated cost figures were given: figured on a per-student basis in a 10-week course, the cost of using a punchboard-tutor was 20 cents, the cost of using a trainer-tester was less than one dollar, and the cost of using equipment only was $2.10. These estimates ignore developmental costs and are based on replacement or consumption expense.

An interesting sidelight is that exactly the same problems can be programmed on the punchboard as were programmed on the trainer-tester; these, of course, were the same problems as those presented on the equipment.

Carpenter, C. R., chairman. *The Classroom Communicator.* Technical Report SDC-ONR, University Park: Pennsylvania State University, October 1950.

The Classroom Communicator is a group-type learning machine and hence falls outside the usual criteria for other devices in this bibliography. An elaborately wired special classroom was devised in which each seat was equipped with a semi-private (hidden) response button. The instructor at the front of the classroom presented on film a multiple-choice question, and each individual responded at his seat by pushing the appropriate answer button. The response was recorded on the instructor's panel. A cumulative record was kept for each student, as well as for the entire class. Immediate knowledge of results was available to the students by showing the answer following each question. Responses could be timed.

This device lacks the characteristic of rate flexibility, having been developed originally as a film rater or film analyzer in part. There are numerous film analyzers which work on the basis of an individual resistance valve at each seat. The student gives information to the instructor or to the machine by turning the dial on the resistance valve. General Electric Company makes perhaps the best known response analyzer.

Carpenter, Finley. "How Will Automated Teaching Affect Education?" *The University of Michigan School of Education Bulletin,* October 1959.

This is an introductory article giving the principles behind the rapidly expanding teaching machine movement.

Carr, William J. *Self-Instructional Devices: A Review of Current Concepts,* WADC Technical Report 59-503, Aerospace Medical Laboratory, Wright-Patterson Air Force Base, Ohio, August 1959.

A selective review of the literature on self-instructional devices is presented, with emphasis on those studies which provide for a functional analysis of such devices. Three major classes of variables which influence the effectiveness of learning by means of self-instructional devices are: characteristics of the device, characteristics of the program, and characteristics of the learner.

Major attention is devoted to an analysis of the process of programming, or the arrangement of the materials to be learned in proper sequence which maximizes rate of learning and degree of retention. Discussion is focused on a number of variables of which the effectiveness of the process of programming might be a function. Some of these variables have not been subjected to experimental analysis. A working model is presented, based upon the familiar processes of conditioning. (by Carr)

Cornell, Francis G.; Damrin, Dora E.; Saupe, Joseph L.; and Crowder, Norman A. *Proficiency of Q-24 Radar Mechanics: III. The Tab Test—A Group Test of Trouble-Shooting Proficiency.* Research Bulletin AFPTRC, TR-54-52, Air Force Personnel and Training Research Center, Lackland Air Force Base, San Antonio, Texas, November 1954.

This article includes a general description of the Tab Item, developed to train proficiency in trouble shooting by use of a simulated device rather than actual electronic equipment. In using the Tab Test device, the symptom is printed at the top of the first page of an item (an item is usually several pages long). Following the symptom description is a list of check procedures and a list of possibly defective units, printed on the left hand of the page. Opposite each check procedure at the right hand side of the page is a verbal or diagrammatic description of the results the mechanic would obtain if he carried out the described check procedure, such as the voltage reading, a wave form, etc. The mechanic makes the simulated check procedures by tearing off a cardboard overlay. Each cardboard overlay has a number printed on it; after it is torn off, it is hung on a spindle. After the mechanic has performed what he considers an adequate number of check procedures, he is asked to point out the defective unit. To do this, he turns to the page which lists the number of units; at the right of each unit there is a tab. When he pulls the tab, he is told either "yes, it is the right unit," or "no, it is the wrong unit"; in the latter case, he may make further check procedures and try another item. His performance is recorded and rated by the total number of tabs pulled and by the order in which they are placed on the spindle. The more efficient mechanic generally will pull fewer tabs to arrive at the correct answer (namely, the defective unit).

The Tab Item device is unique in that it provides for a relatively large amount of feedback information, while at the same time performing the function of a test. It was actually designed more as a testing device than as a low-cost training device. Attempts were made to score the Tab Test on the basis of speed and accuracy, as well as logic. Speed was measured by the number of tabs pulled; in other words, the number of simulated operations. In their conclusion, the authors suggest that the Tab

Test and various modifications of it may be used in training situations to provide practice in utilizing logical and systematic processes in trouble shooting. They also suggest that the Tab Test could be a useful device in training areas outside of electronics.

Corrigan, Robert E. "Automated Teaching Methods." *Automated Teaching Bulletin*, September 1959.

This is a general introductory article on the subject of teaching machines.

Coulson, J. E. *Programming for Individual Differences.* Abstract of paper presented in a Symposium on Automated Teaching, Western Psychological Association, San Diego, April 1959.

Coulson declares that a successful teaching machine should be capable of modifying its own behavior in response to information received from the student.

Coulson, J. E. *An Experimental Teaching Machine for Research at SDC.* Technical Memorandum, System Development Corporation, Santa Monica, California, October 1959.

This is an amplification of the July 1959 Field Note by Coulson and Silberman. Coulson feels that simple teaching machines such as Skinner's and Pressey's are inferior because they do not change the program based on students' responses, explain errors, nor give more items if the first response is incorrect. These faults can be remedied by the use of a small computer as is being planned.

Coulson, J. E., and Silberman, H. F. *Proposal for Extension of Automated Teaching Projects.* Field Note, System Development Corporation, Santa Monica, California, July 1959.

The view is held that present designs for teaching machines are limited by their lack of adaptability to individual student needs. Future goals of automated teaching projects would include the development of a computer-controlled experimental teaching machine incorporating a large degree of adaptability. After initial experimentation, a smaller machine which incorporates the essential characteristics of the larger machine would be developed; finally, possible usages throughout all educational systems (including academic, industrial and military applications) would be investigated.

The authors believe that two years will be required to develop an effective computer-controlled teaching machine and instructional items designed to teach symbolic logic. At the same time, some investigation will be made of the teaching of computer programming. A third year will be used to investigate other subject areas, and to determine general principles of teaching machine design and item construction. A study of the interaction of teaching machines with other components of the educational system might require another two years, making a total of five years. During the final two years, it might be possible to develop a more simplified teaching machine design which would still incorporate all essential elements.

The authors estimate that the needed capacity of the computer would be 2000 words of internal storage, and 5000 words of external storage. The speed of computer operation is not critical. Most small computers possess more than enough computational speed to keep up with human responses. What computer is used will depend upon a number of considerations. A very large computer (IBM 709) may be utilized because it is available for general use.

Or, one of the smaller computers, such as the Librascope LGP 30 or the Bendix G 15 may be purchased for this specific project. The availability of input-output devices of a suitable nature also is a consideration.

Coulson, J. E., and Silberman, H. F. "Effects of Three Variables in a Teaching Machine." *Journal of Educational Psychology,* Spring 1960.

Eighty junior college students divided into eight groups were given experimental training on a simulated teaching machine consisting chiefly of a screen with the experimenter on one side performing the function of a teaching machine and the subject on the other. The three independent variables were: (1) size of steps, large or small; (2) mode of response, constructed or multiple choice; and (3) branching versus no branching. The "branching," sometimes called "forward branching," is a procedure which allows the student to skip over certain items which cover the same concept, if it is demonstrated that he already knows the concept. The criterion test consisted of half multiple-choice items and half constructed items.

No significant difference was found between modes of responding (that is, whether multiple-choice or constructed).

Small step items required more time but yielded significantly higher test scores than did large step items on the constructed response criterion subtest.

Branching conditions generally did not show a significant difference on the criterion test except that they required less time when steps were skipped. However, factor analysis did show that the constructed response non-branching group had a higher mean criterion score. The above results were obtained on the constructed response criterion test only.

The multiple-choice criterion test showed no significant difference between experimental groups. A significant difference was shown between all the experimental groups and the control group which had no special training.

Cross, K. Patricia, and Gaier, E. L. "Technique in Problem Solving as a Predictor of Educational Achievement." *Journal of Educational Psychology* 46:193-206, 1955.

The authors used a Tab Item Test to study preferences for fact versus preference for principles in what they call the BPT (Basic Problem Test). They found that mathematics students prefer principles. Problems which used "facts" were rated easier, but students choosing these problems made more mistakes in arriving at solutions. The authors concluded that BPT is a better predictor of mathematics grades than are language or non-language IQ. The authors made some interesting comments on the use of the Tab Format, to wit:

"The Tab Format of the BPT provides a situation in which the subject is able to select the kinds and amount of information he believes will best enable him to solve problems. This technique might extend to those applied situations where the effects of knowledge of results and subsequent test behavior can be measured as well as a large number of selected personality variables (for example, motivation, rigidity, perseveration). The effects of the ambiguity offered by the more abstract principles might possibly be extended to measure personality."

The Tab Method might well be applied to situations where the initial selection and use of a specific series of

procedures is an important aspect of the individual's subsequent training.

This study was done in cooperation with the Air Force Personnel and Training Research Center.

Crowder, Norman A. *The Concept of Automatic Tutoring.* Organizational paper, Air Force Personnel and Training Research Center, ARDC, Lackland Air Force Base, Texas; cited by Darby, 1959.

"Automatic tutoring attempts to simulate the entire learning situation without either an instructor or the apparatus which is the subject of instruction. The student is presented with a book in which he finds a question followed by a list of alternative answers. Choosing the answer he thinks correct, he turns to the page the answer indicates and finds whether he is right. If not, he is informed what was wrong with his answer and instructed to return to the original page and try again. When he is correct, the text gives him more information and leads him to the next question. The main disadvantage of this method of instruction is that the student is clued by the list of possible alternatives, the author says. He feels that this method has definite possibilities for augmenting direct instruction in a formal or an on-the-job training course at comparatively little cost in time or material."

Crowder, Norman A. *An Automatic Tutoring Book on Number Systems.* Vol. 1, published by Hoover Electronics Co., Timonium, Maryland, 1958.

Presenting this as an example of a "scrambled book," Crowder also refers to this type of book as "automatic tutoring," containing "intrinsic programming." The basic purpose of this book is to cause the student to respond to a carefully programmed series of questions. On the first page there is a brief introduction (in this case, to the binary number system) followed by a simple problem. At the end of the problem there are several answers. If the student chooses the first answer, he is directed to turn to a later page, say 57. If he chooses the other answers, he is directed to turn to a different page, say 89. If the student has chosen the correct answer, the page starts off: "You were correct. Now you need to understand that such is such, etc., and in order to see that you understand, try this problem." A problem is then presented and several more answers are given at the bottom of the page. The student responds by selecting the page number opposite his answer. If he chooses a wrong answer he is told, "You were not correct. The principle you do not understand is such and such. Now go back and attempt the problem again." On some occasions if an answer is given that is egregiously incorrect, the student is referred to an earlier section in the program and made to repeat a larger portion of the program to improve his understanding. At times a completely new feedback loop may be installed whereby the student is taken on a course of remedial action rather than simple repetition of the main program. This, in effect, gives a different curriculum to slow students than to fast students and, of course, changes the length of the program to fit the student's ability.

Three volumes of Crowder's book relate to number systems. They are currently in use in training computer programmers at System Development Corporation in Santa Monica.

Other scrambled books by Crowder include those on Contract Bridge and on Electronics Trouble Shooting originally published by Rheem Manufacturing Company (now Rheem Califone Corporation), in 1957. In answer to a personal query Crowder states that he expects to publish a revised edition of the Number System Scrambled Books through Western Design Company, Santa Barbara, California.

Crowder, Norman A. "Automatic Tutoring by Means of Intrinsic Programming." In *Automatic Teaching: The State of the Art*, edited by Eugene Galanter. New York: John Wiley & Sons, 1959.

Crowder is interested in the question, "How can you use error response?" His answer is obviously, "scrambled books." He states that students will be wrong some of the time in working problems. The question is, in which way will they be wrong? It is apparently his desire to find the common ways in which students make errors and to use this knowledge in planning proper remedial training. This, he feels, can be done by means of his scrambled book.

He states that teaching is a "feedback controlled process." Since individual students vary, their needs will be different; hence, their tutoring should be different.

Crowder believes that multiple-choice methods are easiest to work with. Free response methods are more difficult to handle by automated tutoring processes.

Crowder defines "automatic tutoring" as individual instructorless tutoring, presenting material in small logical units, each unit being tested immediately. The test results should then determine automatically subsequent presentation of data, either new or review. This can be done through the use of the scrambled book or a microfilm reader with a scrambled-book type of programming.

Crowder defines "intrinsic programming" to mean that alternate programs are built into the basic material. It should be noted here that the programming provides for individual differences. One of Crowder's hypotheses is that the teaching of meaningful material requires considerable covert activity on the part of the student, that is, "thinking," and that the form of the response that the student makes to the teaching device is essentially irrelevant.

Damrin, Dora E., and Saupe, Joseph L. *Proficiency of Q-24 Radar Mechanics: IV. An Analysis of Checking Responses in Trouble Shooting on Tab Test Problems.* Research Bulletin AFPTRC—TR-54-53, Air Force Personnel Research Center, Lackland Air Force Base, San Antonio, Texas, November 1954.

In using the Tab Item Test the authors formulated seven hypotheses about trouble-shooting procedures. They attempted to define procedures used by successful efficient mechanics as distinguished from those used by less efficient mechanics. This report has implications for the organization of the content of trouble-shooting training.

Darby, Charles L. *An Annotated Bibliography on the Automation of Instruction.* Draft of research memorandum, Joseph C. Hammock, Director of Research, U. S. Army Air Defense, Human Research Unit, Fort Bliss, Texas, April 1959.

An annotated bibliography of 91 items on teaching machines and general theoretical textbooks. All applicable references are included in the present bibliography.

Dowell, E. C. *An Evaluation of Trainer-Testers.* Training Analysis and Development Directorate, Headquarters, Technical Training Air Force, Gulfport, Mississippi.

This is a large scale evaluation of the Trainer-Tester. Some 26,000 Trainer-Testers using super-heterodyne receiver circuit as the curriculum were used in training at Keesler, Lowry, and Scott Air Force Bases. The experimental population consisted of four matched groups of students in the 13th week of basic electronics training. The groups were identified as follows:

1. The control group, which received instruction in trouble shooting on the actual super-heterodyne receiver only.

2. Experimental Group 1, which received instructions in trouble shooting and trouble-shooting problems on both Trainer-Testers and actual equipment.

3. Experimental Group 2, which received instructions in trouble shooting and practiced trouble shooting on problems on the Trainer-Tester only.

4. The pre-test group, which received general instructions in trouble shooting but did not practice trouble shooting by any method.

The criterion measure consisted of three representative trouble-shooting problems on actual receiver equipment. Evaluation of results was based on (1) whether or not the defective part was identified and (2) the amount of time required. In addition, a questionnaire was employed to obtain student reaction.

Dowell found that Experimental Group 1, which used both equipment and Trainer-Testers, received the highest average scores on the criterion measure. He also found that the achievements of the control group were significantly better than the pre-test group; however, they were not as high as the Experimental Group 1. Experimental Group 2, which used only Trainer-Testers, did not achieve significantly better results than the pre-test group that had no opportunity to practice trouble shooting.

An analysis of the questionnaires showed that 79 percent of the students in Experimental Group 1 and 81 percent in Experimental Group 2 manifested strong interest in the Trainer-Tester. Eighty-four percent of the subjects in Experimental Group 1 and 90 percent in Experimental Group 2 expressed the opinion that the Trainer-Tester provided significant help in learning trouble shooting.

In another section of the study, analysis of a questionnaire given to instructors indicated that 78 percent of the instructors believed that the test did not take too much time to explain and to administer. Some 97 percent of the instructors believed that the trainer-tester had value as a teaching device. All of the instructors believed that the device would increase student ability to read and interpret schematic diagrams.

A study of the time used in completing a problem showed that the average time for one problem for a beginning student was 9.8 minutes. The average time at the beginning of the course was 19.6 minutes. At the end of the course the average time was 7.3 minutes.

The evaluation included a discussion of price. It was found that for this project the purchase price of 50 cents covered a complete set. The evaluators questioned this cost as being unusually low because it was an introductory offer designed to interest the Air Force.

They also noted that the development costs, which run quite high, were borne by the United States Navy.

All but 3 percent of the instructors answered *yes* to the question, "Do you believe a Trainer-Tester of this type designed for material taught in your phase has any value in teaching trouble shooting?" A majority of the instructors felt that Trainer-Testers could increase student motivation, improve student attitudes, teach specific skills, and implement or increase knowledge.

Edwards, Ward. *Skinner's Teaching Machines.* Unpublished draft, Air Force Personnel and Training Research Center, Lowry Air Force Base, Colorado, May 1956.

This is an early summary of teaching machine devices that Skinner had in progress in early 1956. Edwards states that Skinner's first machine was a simple multiple-choice machine which handled simple multiple-choice questions, with a response mechanism consisting of four buttons. In description, this device seems to be very similar to Briggs' card-sorting device reported earlier. However, in the latter part of 1958 Skinner did have a simple multiple-choice machine under way which was used primarily to teach reading-readiness material.

The second Skinner machine reported by Edwards was the arithmetic machine which worked by sliders and a paper tape. The student could make responses of any number from zero through 9999. When he felt he had set the sliders at the appropriate number, he turned a crank which locked the sliders in place. The student was then able to obtain knowledge of results.

The third machine reported by Edwards was a multi-purpose disc write-in machine. (A more detailed report of this device is given in a later reference by Skinner.) This machine was developed at Harvard under Skinner in cooperation with James Holland. Late in 1958, the Special Devices Center of the ONR, Port Washington, was constructing a small battery of these machines for experimentation.

Edwards calls machine number four still only "a gleam in Skinner's eye." In this device a student writes answers on a typewriter keyboard which is attached to a computer. The computer gives him knowledge of results. Part of Skinner's gleam has become a reality through the IBM teaching machine project (Rath, 1958). Another reality is the research being done by Rheem Manufacturing Company, in cooperation with Gordon Pask and the Solotron Company in England. These companies have developed a punchboard training device and currently have on the drawing boards devices which will teach adding machine operation and typewriting. Further reference to this device appears under Rheem Manufacturing Company.

Edwards sees several principles involved in Skinner's teaching machines. First, immediate feedback; second, flexible rate; third, self motivation; fourth, convenient methods of reinforcement. He postulated that devices should have a variable ratio schedule, that is, the student should be given a nickel or some other intrinsic reward every *n*th trial with the *n* varying around some mean value. An example of this would be the typical slot machine pattern of reinforcement.

In a discussion on principles of programming Edwards pointed out that the Socratic method with a minimum of

exposition and a maximum of active participation was desirable. Furthermore, steps between questions should be small, so that the student will seldom be wrong. This is important to maintain motivation and to assure understanding. The material should follow logical progression rather than a "rote learning" process. He feels that by "understanding," Skinner means a rich associative context for the concept being taught. Skinner also makes use of crutches or prompts which are artificial devices to help the student select and remember the answer, for example, printing difficult letters in a spelling question in red. Another of Skinner's programming principles is "vanishing," which is discussed more fully later.

Edwards concludes that Skinner's principles of programming have important implications for Air Force training.

Eigen, Lewis D. *The Construction of Frames of an Automated Teaching Program.* Collegiate School Automated Teaching Project, November 1959. (Copyright)

Single frames of a program have three components: (1) the *operation* requiring the student to do something, (2) the *data* information he will use, and (3) the *instruction* which is usually "go on to next frame" but may be "see teacher" or "see book."

Eigen also classifies frames into (1) *panels* which simply supply information, (2) *review*—no data, just an operation and instruction, (3) *instruction* only, and (4) *forced frame*—student is forced to respond correctly by obvious nature of answer.

Cues suggested by the author include color, spatial relations, emphasis (underlining), and demonstrating (arrows and other devices).

Evans, James. *Conversion to Number Bases Other Than Ten.* Unpublished programmed text, Department of Psychology, University of Pittsburgh, August 1958.

In explaining the programmed text, Evans states: "The task of the reader in this textbook is to read the response panel and write his answers on a separate sheet. He then proceeds to the check panel and checks his answers and reads the additional material."

A check panel uses approximately one-third of the page. After the student has read the response panel and responded on a separate sheet of scratch paper he then turns the page in the corresponding check panel. Thus the student works his way through to the end of the book three times. Evans instructs the student to attempt to answer all items, stating that if the check panel is used before you answer the response panel, the textbook will be useless. If the student misses several panels in succession, he is instructed to go back and repeat them.

Fattu, Nicholas A. *A Catalog of Trouble-Shooting Tests.* Report No. 1, prepared for the Personnel and Training Branch, Psychological Sciences Division, Office of Naval Research, by the Institute of Educational Research, Indiana University, December 1956.

This catalog surveys tests in the following groups: (1) on-the-job measures, (2) performance tests, (3) simulator tests, (4) ARC (automatic recording of checks) or tab-type tests, and (5) paper-and-pencil and oral interview tests. Most of the items described were developed under military contract. The catalog mentions Grings' Masts Test and the Automasts Test developed by Bryan and others. Also included is the Automatic Rater device (punchboard), the Trainer-Tester, the

trouble-shooting board developed by Glaser and Phillips at the American Institute for Research, as well as other studies by Briggs and Besnard, and Cantor and Brown, which are mentioned in this bibliography.

Fattu mentions numerous sources of interest to compilers of this type of bibliography. Chief sources are: (1) the Armed Services Technical Information Agency Title Announcement Bulletins, (2) Human Resources Research Office Bibliography, (3) Psychological Abstracts, (4) Reviews of Educational Research, (5) information obtained from the Personnel and Training Branch of the ONR, (6) Special Devices Center of the ONR, (7) Human Resources Research Center, (8) American Society for Engineering Education, (9) Technical Education News, and (10) Industrial Arts and Vocational Education.

Fattu, Nicholas. "Training Devices." *Encyclopedia of Educational Research,* 3rd edition, The Macmillan Co., New York, 1960.

This article gives prominent mention to teaching machines of the type covered in this bibliography.

Ferster, Charles D., and Sapon, Stanley M. "An Application of Recent Developments in Psychology to the Teaching of German." *Harvard Educational Review,* Vol. 28, No. 1, 1958.*

This article describes an interesting application of Skinner's teaching machine principles with a minimum of equipment usage. The chief part of the device is simply a mask which permits the presentation of mimeographed material one line at a time. Ferster and Sapon use the device for teaching German. The student exposes a line of English and then responds on another sheet of paper by writing a translation. He next slides the paper up one line to expose the correct answer. In the margin of the mimeographed paper he checks himself correct or incorrect. He then proceeds to the next item. The mimeographed sheet is reviewed until a criterion of two correct responses is achieved. The authors point out that the device gives immediate reinforcement for small units and that motivation is not hindered by frequent failure because the material is programmed in small steps. They also point out that the device uses no "adverse" control. They state that good study habits are not required because the machine has built into it a set of good study habits which the student follows while working it.

The authors claim a high degree of specificity of reinforcement, pointing out also that an increasing number of errors decreases the ratio of reinforcement. This is probably an insight from Ferster who worked with Skinner on the book, *Schedules of Reinforcement.* Lessened motivation, they feel, is caused more by an increase of errors than fatigue. In this study, the vocabulary control was not limited to high frequency words as are many elementary texts, but they did have a careful control of over-learning. They introduced new factors one at a time and were careful about grading the difficulty level.

The authors feel that this device has real importance for the classroom: "The principle of continuous mastery is particularly important in learning cumulative skills such as foreign languages. A temporary lapse of effort or attendance in an early stage of a course frequently makes it difficult if not impossible for a student to assume his studies

with the class as a whole at a later period."

In an actual experiment 17 volunteer graduate students at Harvard were taught German. The students had no previous knowledge of German. Only six out of 17 students completed the course. Their mean time was 47.5 hours. Their mastery of reading German was comparable to students who completed a first semester course consisting of 48 hours of instruction plus a recommended 96 hours of homework. However, it should be noted that this mastery was limited to reading ability and had no reference to listening or speaking ability. In spite of the author's careful attempts to grade the material, an uneven difficulty was noticed. The authors felt that attrition tended to occur at the more difficult spots. The chief weakness of this study seemed to be the high percentage of drop-outs. This was probably due to the extreme do-it-yourself nature of the program.

Finn, James D. "Automation and Education: III. Technology and the Instructional Process." *Audiovisual Communication Review*, Vol. 8, No. 1, 5-26, Winter 1960.*

This article is concerned with the implications of mechanical technology on education, with some speculations about the future. Teaching machines are defined as all teaching equipment designed for individual or near individual operation, but "true" teaching machines are the Skinner or Pressey type. The author envisions machines such as the Didak being used in coordination with filmed or TV courses. He warns that school systems could even be eliminated by use of TV, libraries with teaching machines, and an examination certification system run by the Education Testing Service. Finn feels that audiovisual specialists are the proper persons to handle teaching machines in the school system.

Folley, John D., editor. *Human Factors Methods for System Design.* Report AIR-290-60-255, The American Institute for Research, Pittsburgh, 1960.

A survey of teaching machines is included in a chapter by A. A. Lumsdaine entitled "Use of Self-Instructional Devices."

Freeman, James T. "The Effects of Reinforced Practice on Conventional Multiple-Choice Tests." *Automated Teaching Machine Bulletin*, September 1959.

Freeman used an electric version of the Pressey punchboard. When the subject inserted a penlight stylus into the correct hole, the light on the pen lit up, indicating that the response was correct. The total number of responses made to get a correct one could be tabulated.

In a large introductory psychology course the punchboard was used by an experimental group taking two 50-item exams, approximately four weeks apart. Their performance was compared on the final exam with a matched control group.

An analysis of items on the final exam which were relevant to earlier specific reinforced exams revealed that there were no effects of reinforcement. Freeman offers three possible explanations for this: (1) there was an insufficient amount of reinforced practice, (2) the final items were not identical with earlier items, and (3) only a small attempt was made systematically to program the reinforced test material. His conclusion is that, under typical conditions of classroom testing, the casual use of reinforced practice has little effect upon performance.

In another experiment performed with advanced psychology students previously reinforced in a similar type situation, items previously reinforced were compared with non-reinforced items. The differences, although not statistically significant, favored the reinforced items. Freeman suggested the possibility that students of lower ability level were benefited more by the reinforced practice.

In a test-retest situation where the experimental group received reinforcement and the control group did not, the mean gain for the reinforced group was five points and for the control group, .15—a ratio of approximately 30.

In another part of the experiment, identical items were used in similar testing, except that one-half of the test was composed of objective items and the other half of completion items. Freeman found that reinforcement procedures resulted in significantly better performance on the objective items but no significant difference on the completion items.

In another section of the study, Freeman attempted to investigate the differences in systematic programming versus programming without any system. He feels he has demonstrated that there are some benefits to be derived from a systematic program.

Fry, Edward B. *Teaching Machine Dichotomy: Skinner Versus Pressey*. Paper presented at the American Psychological Association Annual Convention, Cincinnati, September 1959. (In press, *Psychological Reports.*)

Contrasts are shown in several areas affecting teaching machines. (1) Skinner prefers constructed responses while Pressey prefers multiple-choice responses. (2) Skinner prefers that the student make little or no error while responding; Pressey permits some error. (3) Pressey is more interested in having his devices supplement regular instruction, while Skinner and his followers in some instances advocate that teaching machines replace traditional instruction methods. (4) Skinner feels that bright and dull students progress equally well and are treated the same in terms of teaching machine programs, while Pressey would have completely separate programs for very superior and superior students.

Practical applications of Pressey's devices include his Drum Tutor and punchboard; Briggs and Besnard's Subject Matter Trainer; and Crowder's Scrambled Book. Practical devices for Skinner include the Disc Machine, the slider-type arithmetic machine, and Ferster and Sapon's Cardboard Sleeve device.

Fry, Edward B. "Teaching Machines: The Coming Automation." *The Phi Delta Kappan,* October 1959.

This article is an introduction to the field of teaching machines for teachers. It contrasts teaching machines with audiovisual devices, and points out such interesting characteristics as flexible rate of presentation, immediate knowledge of results, and the fact that teaching machines are in harmony with progressive educational practice which uses only positive rewards and emphasizes activity. Traditional audiovisual devices do not require student-material interaction. More conservative educational advantages are the motivation of the academic program, the fact that teaching machines can be fitted into nearly all subjects in the curriculum from mathematics to foreign languages, and that more capable students can progress to

the limits of their capabilities. They also provide improved feedback to the student, to the teacher and to the curriculum supervisor. Properly programmed, the use of machines encourages structuring of good teaching methods and a resultant improvement in curriculum standards. Machines are seen as a valuable aid in educational research, since they can eliminate the "teacher variable" when comparisons are to be made of different methods. Of special benefit is the use of machines in the instruction of exceptional children (both bright and dull) as well as in small schools whose curriculum offerings are limited.

Fry, Edward B. *Teaching Machines: An Investigation of Constructed Versus Multiple-Choice Response Modes.* Unpublished doctoral dissertation, University of Southern California, Los Angeles, 1960.*

Approximately 150 ninth-grade students were taught Spanish words and phrases under two different response modes (constructed and multiple-choice) and three different conditions to control the time variable. A window cardboard folder was used which permitted the exposure of one line at a time under teaching machine type conditions. Evaluation test used both constructed and multiple-choice items. Near maximum score was obtained for all groups using mutliple-choice items so that constructed evaluation gave the only significant differences. Even when training time and timing plus the number of repetitions were held constant, constructed responses were superior.

The author concludes that if recall is the goal of training, then constructed responses are more effective, given conditions similar to the experiment.

The complete dissertation on microfilm can be obtained from University Microfilms, Ann Arbor, Michigan. An article based on the dissertation is in Lumsdaine and Glaser's book, *Teaching Machines and Programmed Learning: A Source Book.*

Gagne, Robert M. *Teaching Machines and Transfer of Training.* Paper presented in the Symposium on Research Issues in the Study of Human Learning Raised by Developments in Automated Teaching, American Psychological Association Annual Convention, Cincinnati, September 1959.

Gagne states that variations in the S (stimulus) and/or the R (response) yield generalizability. This aids in the transfer of training. He was interested in various problems related to transfer, such as generalizability versus interference. He questions whether machines can promote real understanding.

Galanter, Eugene. *Chairman's Introduction and Summary of Conference.* Abstracts presented at Air Force Office of Scientific Research and the University of Pennsylvania Conference on the Automatic Teaching of Verbal and Symbolic Skills, Philadelphia, December 1958.

Nearly all of the abstracted papers presented are mentioned in the present bibliography. Galanter reports conference agreement on these points: (1) the student learns something using automatic devices, (2) this is done in a reasonable time and perhaps in a real saving of time, (3) sequential variables in programming are critical, (4) steps in programming should be small. The areas which lacked agreement were: (1) the form of steps to be used, that is, the multiple-choice versus free response, and (2) error-rate, that is, should the ideal program contain no errors?

In summary Galanter saw the teaching machine program and its structure

to be the critical features of the program, even though some programs use no machine at all (such as book devices). Galanter also noted that all of the discussion was on visual input materials. The use of auditory and tactual inputs was hardly mentioned probably because visual input materials are easier to construct; nevertheless, the importance of other types of input should not be overlooked, Galanter cautions.

From the scattered empirical findings presented at the conference there seemed to be a trend to gear machine teaching to the lower intellectual levels. Galanter observed that it might be most reasonable to design these programs for the less capable, while allowing the more capable to proceed in their own manner. He suggested that a similar conference be held in several years.

Galanter, Eugene, editor. *Automatic Teaching: The State of the Art.* New York: John Wiley & Sons, 1959.

This book is based on the Teaching Machine Symposium held at the University of Pennsylvania in December 1958, sponsored by the Air Force. A number of participants in the conference contributed articles based on their symposium presentations. Most of these are referred to here under the authors' names.

Gilbert, Thomas F. *Some Recent Attempts at the Partial Automation of Teaching: A Report to the University of Georgia.* Unpublished paper, 1958; cited by Darby, 1959.

"The author describes the 'initial steps that have been taken to translate contemporary principles of learning into semi-automated classroom application.' Several teaching machines are described in detail. One, a very simple device constructed from manila folders, was used with a program in college psychology. The results of its use are reported. This paper was the basis for a subsequent report by the same author to Bell Laboratories." (from Darby)

Gilbert, Thomas F. *An Early Approximation to Principles of Programming Continuous Discourse, Self-Instructional Materials.* A Report to Bell Telephone Laboratories, Inc., Murray Hill, New Jersey, September 1958; cited by Darby, 1959.

"The author catalogues experimentally derived principles of learning and discusses their application to teaching. Although difficult, or impossible, to apply in the typical classroom, these principles have recently been incorporated in a learning situation through the development of teaching machines and programmed teaching materials. Several machines are described. Tentative rules for the construction of teaching programs are advanced and illustrations of their use are given. Procedures for analyzing programs and ways of classifying items in a program are proposed." (from Darby)

Gilbert, Thomas F. *An Early Approximation of Principles of Analyzing and Revising Self-Instructional Programs.* Paper presented at the Conference on Teaching Machines, University of Pennsylvania, December 1958.

Gilbert speculates that machines may not be *the factor* but rather that the most important factor may be the development of new methods of programming. He suggests that a variable program for rapid learners could be installed so that the student would work only every fourth item, until he makes a mistake; then he could go back and review the previous three items. It is possible that in some subjects, under

certain conditions, the more capable students would work every 25th item.

Gilbert classifies programming into 11 categories, as follows:

1. *Lead-in items.* These items do not require new information, nor do they require rehearsal of old skills. Their function is simply to orient the student to a problem and prepare him for new information.

2. *Augmenting items.* These items supply new information but do not require the student to make a relevant response. If a response is required, it is designed to insure that the student has read the item.

3. *Interlocking items.* These are items that require a student to review established skills while new information is being presented.

4. *Rote-review items.* These items present a problem identical to one presented earlier. They are not especially recommended, except in short cases where memorization of verbal material is desired.

5. *Restated review items.* These items require a rehearsal of the skill where a problem is restated. Review items are common in most teaching machine programs, especially in the one that Gilbert helped to design at the University of Georgia for teaching algebra.

6. *Delayed-review items.* These are items which allow for the distribution of practice; they differ from other items only in time of presentation.

7. *Fading items.* These require the student to review what has been presented; in addition, they withdraw information successively. (Probably very similar to those used in Skinner's "vanishing technique.")

8. *Generalizing items.* These present a verbal statement pointing to a common characteristic of several specific problems already presented to the student.

9. *Specifying items.* These are items which exemplify a general rule or principle.

10. *Dove-tailing items.* These require the student to make separate responses to separate stimuli that otherwise might become confused.

11. *Subject matter items.* Each item should be further classified with respect to its subject matter content, a type of classification which would cut across the above regular classifications.

In an analysis of the teaching machine program at the University of Georgia for teaching algebra, the overwhelming majority of items were of the review type. Next in order, used with about equal frequency, were: the lead-in, the augmenting, the fading, the specifying and the interlocking items. There were no rote items, no revision items, and only a very few delayed-review items.

Gilbert, Thomas F. *On the Relevance of Laboratory Investigation of Learning to Self-Instructional Programming.* Paper presented in the Symposium on Research Issues in the Study of Human Learning Raised by Developments in Automated Teaching, American Psychological Association Annual Convention, Cincinnati, September 1959.*

Gilbert expressed fears that using a machine too early in the development of programming will cause the author to design his program to suit the machine. He suggested that the simplest possible materials be used, for example, one student, several cards and a teacher. Write the questions. Try them on the student. The student is always right. Vary the

behavior until learning occurs. Keep working and reward the student; pay is suggested. After the programming has been tried out on 10 students and the errors ironed out, Gilbert thinks that it will work satisfactorily with 98 percent of students. Next, carefully describe the procedure and then automate it.

Glaser, Robert; Damrin, Dora E.; and Gardner, F. M. "The Tab Item: A Technique for the Measurement of Proficiency in Diagnostic Problem Solving Tasks." *Educational and Psychological Measurement* 14:283-93, 1954.*

The Tab Item is described in some detail in the annotation under Cornell. The present article brings out an interesting suggestion on the weighting of scores using the following scale to rate each of the pulled tabs: one, relevant; two, additional; three, redundant; four, inadequate; five, irrelevant. These writers also state that the Tab should use a picture or diagram whenever possible in electronics testing and training.

Glaser, Robert; Homme, Lloyd E.; and Evans, James. *An Evaluation of Textbooks in Terms of Learning Principles.* Paper presented at the meeting of the American Educational Research Association, February 1959.*

Recognizing that traditional textbooks are relatively ineffective in bringing about appropriate behavior, these writers identify learning principles which must be stressed. They are similar to those prescribed by Skinner: (1) overt constructed responses, (2) careful sequence of small steps towards the object, and (3) prescribed order.

The authors feel that Skinner's criteria for efficient learning can be met more adequately through use of a "programmed text." This is a text which requires the student to respond to numerous small steps followed by knowledge of results. Experimental results indicate that the programmed-text group did better than the regular-text group but that they took more time. They also observed that learning takes place as well or better without overt responses. In other words, usual teaching machine type responses (such as writing answers or pushing buttons) are not necessary for learning. They stated further that "to a point, smaller steps increase learning." Further information on the programmed-text is contained in references by Homme and Glaser 1958 and Evans 1958.

Hatch, Richard S. *An Evaluation of the Effectiveness of a Self-Tutoring Approach Applied to Pilot Training.* WADC Technical Report 59-320, Aero-Medical Laboratory, Wright-Patterson Air Force Base, Ohio, July 1959.

A Navy Automatic Rater multiple-choice card teaching machine programmed with items on instrument flying was made available to one squadron in its lounge for two months. Pre- and post-testing compared with a control squadron showed a significant gain in job-information for a squadron having the incidental use of the automatic rater.

Hively, Wells. "Implications for the Classroom of B. F. Skinner's 'Analysis of Behavior'." *Harvard Educational Review,* Vol. 29, No. 1: 37-42, 1959.

Hively gives a theoretical discussion of Skinner's principles of learning. Those cited are: (1) there is need for the rewarding of successive approximations, (2) immediacy of reward is very important, (3) high frequency of reinforcement is important, (4) scheduling of reinforcers can control frequency of response, (5) negative reinforcers are bad because of elicitation of side effects,

and avoidance which may be learned rather than the task.

Other principles mentioned are the need to isolate the subject and the use of a machine in the classroom for adequate reinforcement. With respect to teaching machines he says: "They differ mainly in form of response required—multiple-choice, the construction of an answer from a limited number of letters or numerals, or a written answer which is confirmed by comparison with the correct answer. Each appears to be particularly adaptable to certain subject matter and age levels, but all have in common the presentation of a sequence of problems and provisions for immediate confirmation of response to each problem." (p. 40)

Holland, James G. "A Teaching Machine Program in Psychology." In *Automatic Teaching: The State of the Art*, edited by Eugene Galanter. New York: John Wiley & Sons, 1959.

In this study, 187 sophomores used Skinner's disc-type teaching machines for 10 weeks. The subject matter was related to Skinner's book, *Science and Behavior*. The students worked for a median time of 14 hours to cover some 48 discs of 29 frames each; this meant a total of 1400 different frames. The time to work through the easiest disc ranged from three to 14 minutes, the average being 10 minutes. On discs of medium difficulty the median time was 14 minutes; on the most difficult, 28 minutes. Although students were permitted to distribute the work themselves, they never took more than six discs per session. Seventy-six percent of the students said that the machine helped them in studying. An analysis of performance on the final examination showed that items on which the machine could have been expected to help were much more frequently answered correctly than were items for which the machine work was irrelevant. These are some of the programming techniques used by Holland:

1. Panels consisting of short passages of printed material or graphs to which the student could refer at any time while working the item in the machine.
2. The use of new words in a series of frames before requiring the student to use them.
3. Some items moving from definition to examples within a single frame.
4. Some items using "leading-in" from an assumed knowledge.
5. The indication of relevant categories to which the response terms alone were used in some items.
6. Some items using high association words or common phrases.
7. Avoidance of undesired alternative responses by careful phrasing of the frames.

The strengths and weaknesses of the program were revealed by an item analysis of student responses rather than by the author's armchair speculations.

A further report of this same program entitled *Teaching Psychology by Teaching-Machine Program* was given by Dr. Holland at the 1959 convention of the American Psychological Association.

Holland, James G. *Teaching Machines: An Application of Principles from the Laboratory*. Paper presented at the Invitational Conference of the Educational Testing Service, October 1959.*

After a brief introduction on teaching machines and a discussion of the machines developed at Harvard, the author enumerated seven principles:

1. Immediate reinforcement.

2a. Behavior is learned only when emitted and reinforced.

2b. Punishment (errors) lowers learning rate.

3. Gradual progression to establish complex repertoires.

4. Gradual withdrawal of stimulus support (vanishing or fading).

5. Control of students observing and echoic behavior (attention required).

6. Discrimination training (establishing an abstraction). Machine can provide many examples.

7. Let the student write the program; if the student has trouble with the program the programmer must correct the program.

Holland, James G., and Skinner, B. F. *A Self-Tutoring Introduction to a Science of Behavior.* Unpublished manuscript, Psychological Laboratories, Harvard University, circa 1959.

This is a teaching machine program used by Holland and Skinner in teaching a behavioral science course at Harvard. Copies are available from the authors.

Homme, Lloyd E., and Glaser, Robert. "Relationships Between the Programmed Textbook and Teaching Machines." In *Automatic Teaching: The State of the Art,* edited by Eugene Galanter. New York: John Wiley & Sons, 1959.

The Programmed Textbook or "paper teaching machine" is an especially designed book, each page of which contains four panels, the panels roughly dividing the page horizontally into quarters. A question is presented in the top panel of the right-hand page; the student is expected to read the question and make subjective response; he then turns the page to see whether or not his response is correct, as the answer is printed in a panel on the reverse side of the page. In order to cover all material in the book, the student must go through the book (turn all the pages) four times. The authors feel that a Programmed Textbook is similar to, or fulfills many of the requirements of, a teaching machine, because (1) it allows for the emission of responses, and (2) the programs may be structured in short, well designed steps. The authors realize that cheating is possible but admit that it may not be undesirable from a learning standpoint. The book contains instructions to the effect that the student should repeat items on which he has made incorrect answers. The authors also point out that one of the functions of a modern teaching machine is to cause the student to emit each response, rather than to select one from a group of suggested alternatives. The authors also feel that the student should be led through a large number of carefully designed steps that minimize the probability of incorrect responses.

The authors report that they are conducting an experiment to compare programmed texts with conventional texts. Preliminary results uniformly support the effectiveness of the programmed text. In an experiment using elementary psychology material, the experimental group was significantly above the control group, and the lower end of the distribution was eliminated. They also found a relationship between errors in the program and errors in the final test. If the steps are too large, time increases and learning decreases. They found that time to work through a given number of programmed text pages does not necessarily increase as the number of panels increase. In other words, a

greater number of steps might be done if they were easier and the student were able to go fast.

The authors conclude that conventional textbooks are good for the storage of information and for reference, but that they are not good as elementary texts in college.

Homme, Lloyd E., and Glaser, Robert. *Problems in Programming Verbal Learning Sequences.* Paper presented in the Symposium on Research Issues in the Study of Human Learning Raised by Developments in Automated Teaching, American Psychological Association Annual Convention, Cincinnati, September 1959.*

The authors believe that the reason why teaching machines are not being used is that there are no programs. In a discussion of problems in program writing, they proposed a system known as the "Ruleg." This system consists primarily of stating a rule or principle, and giving examples. Both rules and examples may be negative or positive. Each item is either an incomplete rule or an incomplete example. The student responds by filling in or completing the rule or example. In their system of classifying the examples, RU stands for rule, EG stands for example. A bar over the RU or EG indicates a negative example or rule, and a tilde over the EG or RU means that it is incomplete. A typical program sequence might look like this: (1) RU plus EG plus $\widetilde{\text{EG}}$; (2) EG plus $\widetilde{\text{EG}}$; (3) $\widetilde{\text{EG}}$; (4) $\widetilde{\text{RU}}$; (5) EG plus EG plus EG plus $\widetilde{\text{RU}}$; (6) $\widetilde{\widetilde{\text{RU}}}$ (double tilde means very incomplete). (Some of these comments on the Ruleg system were supplied by James Evans.)

Homme, Lloyd E., editor. "Research Notes." *Automated Teaching Bulletin,* Rheem Manufacturing Company, Vol. I, No. 1, September 1959.

In Rheem's first *Bulletin,* Homme's editorial notes summarize research in progress, as follows:

1. The first of these Research Notes is by Nancy Anderson at IBM Research Center where research is undertaken to identify important determiners of efficiency in teaching machines and to develop a special purpose input-output device for the IBM 650 to use for investigations of the automated training process. The experimental research on efficiency will study such factors as spacing between initial presentation and interrogation about the material. It will also study the amount of response evaluated before knowledge of results is to be given. The input-output device (developed by System Simulation Laboratory) will permit the IBM 650 to simulate a teaching machine. Specifications for this device are based upon previous work with the IBM 650 in teaching binary arithmetic.

2. Earlham College has received a three-year grant from the Department of Health, Education and Welfare under Section VII of the National Defense Education Act, for the study of the possibilities of automated teaching and the study of various ways in which principles of modern learning may be more effectively applied to college instruction. John Barlow of the psychology department is in charge of this project.

3. Jacob Beck of the University of Pennsylvania, in cooperation with Shaw and Mather, is completing a paper for the *Psychological Review* on a theoretical analysis of instruction processing. The paper is concerned with methods to

be used to introduce and guide the student to make appropriate responses in teaching different kinds of subject matter. In an experiment, students were taught some elementary properties of prime numbers.

4. C. D. Ferster at Indiana University Medical Center has received a grant from the Office of Education for a project concerned with the role of reviewed material in continuous programming with teaching machines. One of the questions studied will be the degree of repetition of material that is necessary for proper retention. Ferster states that the problem has practical importance for design because a machine that would accomplish essentially the same objectives as the $500 ones could be constructed for $10 to $30 if the mechanism for repeating missed items could be eliminated. It is the provision for review or repetition of missed items that makes teaching machines expensive, he comments.

5. A preliminary report of Fry's investigation comparing multiple-choice versus constructed responses is included in the Research Notes. Further information on this is reported under the author's name in this bibliography.

6. Robert Gagne of Princeton has received a grant from the Carnegie Corporation to investigate learning and the use of mathematical concepts in problem solving. The basic hypothesis is that problem-solving performance can be accounted for by differences in the adequacy of underlying concepts. Learning materials are being prepared to establish different degrees of concept adequacy.

7. Hamilton College at Clinton, New York, has received a $204,000 grant from The Fund for the Advancement of Education to program first-year courses in French, German, mathematics, philosophy and psychology for teaching machines and to study the methods used over a two-year period by 300 students enrolled in these courses. In cooperation with the psychology department, machines using 16mm films have been developed. An instructor has been added to each of the five departments so that released time of other department members can be used for programming. Students will be scheduled for four or five half-hour work periods on 30 machines. Each machine will be in use seven or eight hours per day. Forty items are presented on one programmed card, which, once inserted into the machine, cannot be withdrawn until all items have been completed. An auditory machine designed for work in language and music can be controlled from the visual machine, or can be operated independently. It is expected that programs will contain from six to 10,000 items when completed. Several of the programs may be tried out on high school students during the second year of study.

8. James Holland at Harvard announces that programs based on Skinner's *Science and Human Behavior* are available for $15 a copy.

9. Homme, Glaser, Evans and Stelter have a program on elementary statistics in press. In addition, Evans has a program on symbolic logic and is working on an integrated mathematics program.

10. The American Institute for Research has three projects under the direction of A. A. Lumsdaine on applying learning theory with particular reference

to audiovisual media and teaching machines. The first project involves the use of television presentation for demonstration lectures in high school physics, with a teaching machine program for follow-up. The second study is a basic research on cuing methods involving various forms of contextual and semantic prompts. The third method involves development of programs for SAGE operations.

11. Francis Mechner of the Schering Corporation, Bloomfield, New Jersey, is writing an algebra program. Five hundred of an estimated 3000 frames have been completed.

12. John Modrick of Aero-Medical Laboratories, Wright Air Development Center, Dayton, Ohio is investigating three principal conditions, presumably with reference to the Subject Matter Trainer. First is the mode of operation of the trainer, second the criterion of mastery of the material to be learned, and third the type of task.

13. Richard Schutz at Arizona State University reports that several machines similar to Porter's are being built and some items written appropriate to college and elementary school levels.

14. George Spivack of the Devereau Foundation, Devon, Pennsylvania, reports that they are trying Porter's sixth-grade spelling program on atypical children and that a number of different machines have been built and are under investigation.

15. Lawrence Stolurow, University of Illinois, has received a grant from the Office of Education for research on programming factors.

16. Loche Van Atta of Oberlin College has received a Ford Foundation grant to support programming in introductory psychology, genetics and music theory, with the possible addition of logic and freshman mathematics next year.

17. Wright Air Development Center reports that they are in the process of launching a substantial program on the research of automated teaching systems. They are soliciting employees.

18. Lumsdaine and Glaser, at the American Institute for Research in Pittsburgh, are compiling a book for the National Education Association entitled *Teaching Machines and Programmed Learning: A Source Book*, to be published in May 1960.

19. Deutsch and Potts at Rheem Research Laboratory in South Gate, California report that they have two research projects related to psycho-motor skill under way. The psycho-motor tasks are key punch operations and code receiving and transmission. The SAKI device is being used in the key punch investigation.

Irion, A. L. *An Investigation of Four Modes of Operation and Three Types of Learning Tasks on the Improved Subject Matter Trainer.* Unpublished draft, circa 1957; cited by Darby, 1959.

"The comparative effectiveness of four modes (quiz, modified quiz, practice, and single-try) of practicing on the Improved Subject Matter Trainer was investigated with three types of learning tasks (paired-associate, serial, and problem solving). The comparative effectiveness of the modes appears to be related to the type of learning task, and mode may possibly be confounded with the difficulty in learning the task. There was no statistically reliable indication that transfer of content from the paired-

associate task to the problem solving task had taken place." (from Darby)

Irion, Arthur L., and Briggs, Leslie J. *Learning Task and Mode of Operation Variables in Use of the Subject Matter Trainer.* Technical Report, Air Force Personnel and Training Research Center, Lowry Air Force Base, Colorado, October 1957.

This experiment uses the Subject Matter Trainer described by Briggs, 1958, together with its modes of operation. In this experiment the modes varied in effectiveness in descending order, as follows: (1) quiz mode, (2) modified quiz mode, (3) practice mode, and (4) single-try mode. In the quiz mode the student quizzes the machine. In other words, he merely presses a button which always shows the right answer and is instructed to attempt to remember the right answer; he then presses another button which causes the machine to proceed to the next item if the response is correct. The same mode is referred to by Briggs, as the "coaching mode." In the modified quiz mode, second in effectiveness, the student is told the correct answer after the first try. Briggs referred to this as the "single-error permitted mode."

The authors account for the superiority of the quiz mode as a result of the following four factors:

1. No time is lost searching for the correct response, so more trials per time unit are accomplished.

2. Overt wrong responses are avoided, although covert wrong responses are possible if the student fails to follow directions precisely.

3. No signal, buzzer or red light for a wrong response is ever received.

4. There is a close temporal continuity between presentation of the stimulus and the appearance of the green light.

This experiment did not compare learning rates on this and on more conventional devices. However, the authors did state that the modes of operation of the Subject Matter Trainer were "surprisingly effective," and that the results of the study appeared to justify further use of the Subject Matter Trainer. However, they suggest that a simplified model could be used for operational use; this modified model would handle only the quiz and modified quiz modes of operation.

Jensen, B. T. "An Independent Study Laboratory Using Self-Scoring Tests." *Journal of Educational Research* 43:134-37, 1949.

Twenty-four superior college students were allowed to take a course in educational psychology using only a special "independent study" laboratory. These students did not attend the regular class sessions. There were no class meetings, but the laboratory was open to them every afternoon during the first half of the school quarter. In the room were various materials, the most distinctive of which were two or more practice tests for each reading assignment. The students took the practice tests on the Pressey punchboard device which immediately informed the student of the correctness or incorrectness of each response. If the student wished to look up his wrong response there was a page reference for each item. He also had the privilege of talking over any item with the laboratory instructor. If he wished, he could repeat a test at any time. A record was kept of each student's work, and friendly free discussions among the students were encour-

aged. Scores on the practice tests did not count toward the final grades. Grades were based on two objective mid-term exams and a final objective examination. Grades were then assigned on the basis of scores in regular class sessions. The course was highly accelerated and a calendar was followed for the examinations which brought the final examination at the end of the first few weeks of the course. However, some students finished earlier and were given the test then. All who finished did so within five weeks of the first test period. There was only one drop-out. Results showed that 51 percent of the students in the independent study laboratory received A's in contrast to 10 percent in the regular sections; 13 percent of the laboratory students received B's and 33 percent received C's. There were no D's or E's. The author concludes that highly motivated students can satisfactorily handle college courses by independent study when guided, and if given the proper materials and procedures. He also pointed out the great saving in time for superior students as well as for the instructional staff.

Jones, Robert Stuart. "Integration of Instructional with Self-Scoring Measuring Procedures." *Abstracts of Doctoral Dissertations*, No. 65, Ohio State University Press, 1954.

This study basically confirms Pressey's 1950 study which emphasizes the desirability of using the punchboard. Jones thinks that the most valuable instruction techniques were "individualizing instruction, the provision of special opportunities for the extremes of the groups, the use of self-appraisal, and diagnostic teaching." He believes that punchboards reach this goal better than do "conventional teaching" methods.

Jones commented on the programming of multiple-choice materials, declaring that items which were especially selected for learning value were better than the typical test-type items. Good learning items are "applicational, pose a definite problem, call more for thinking than for just memorizing, and are between .40 and .60 in difficulty."

Keislar, Evan. *Theoretical Aspects of Automated Teaching.* Paper presented at the Western Psychological Association, San Diego, April 1959.

Keislar states that we do not have a theoretical system for automated teaching. Rather, we have a collection of principles or working hypotheses drawn largely from reinforcement theory. He suggests two other approaches, both of which are being developed: (1) information theory, and (2) game theory.

He cites two types of machines which seem to be at theoretical extremes. The first is a "successive approximations" model developed by Skinner. In this type of machine, the stimulus has a high probability of eliciting the correct response. The second stimulus can very easily be generalized from the preceding item; hence, it also has a high probability of response. Each successive step leads gradually to a predetermined goal.

The second type of machine, which Keislar calls "Ideal," would require a computer with a large storage mechanism. Its chief characteristic is the modification of the program based upon the performance of the learner. In short, the program is adapted to individual differences. Such a device is geared to skipping steps for rapid learners, as well as remedial and enrichment programs. In the ultimate machine, each step would be dependent upon

everything that had gone before. This ultimate machine could have two types of goals: one an objective, instructor-determined, fixed goal; the other determined, at least in part, by the student's preceding performance. Hence we see that even the goal itself may be determined after the student has started performing on the machine.

Keislar is also concerned with some of the problems involved in programming. Stimulus generalizations and response generalizations are fairly obvious. But one thing that must be taken into account in human learning is a mediating generalization. Sometimes this mediating generalization may be planned within the program; usually, however, it would involve prior learning that had occurred elsewhere. The program constructor must, therefore, rely on his own information about the student's previous learning. Since this is little understood, programming is still largely an "art." Keislar mentions two criteria that may be applied: (1) Is the interval between steps small enough to hold the probability of a correct response high? (2) Is the interval large enough to facilitate rapid progress?

Keislar identifies two other problems confronting the program writer: (1) Where to begin? (2) What route or sequence to follow? Though there are no set answers to these problems, automated teaching provides at least an empirical test of them.

Keislar, Evan. "The Development of Understanding in Arithmetic by a Teaching Machine." *Journal of Educational Psychology*, 50:247-53, December 1959.*

Keislar attempted to use a teaching machine to teach understanding of elementary arithmetic. By "understanding" he meant the "ability to answer a variety of questions different from those encountered during training but belonging to the same general class." The apparatus used was a multiple-choice machine, a modification of the "Film Rater" used by the Navy during and just after World War II. Multiple-choice items were printed in a filmstrip which was projected upon a viewing plate just in front of the learner. The learner responded to each item by pressing one of five buttons: if the answer was correct, a green light was shown and the next item could be brought into view; if the answer was wrong, a red light came on. A special device recorded on a graph all errors and correct answers for all items.

The total program consisted of 120 items, the first 10 of which simply told the subject how to operate the machine. The remaining 110 covered a sequence of concepts. The principle used in programming included successive approximations, use of prompts, and secondary generalization. Fourteen subjects were used—fourth- and fifth-graders selected from university elementary schools; they were matched with 14 controls on a pre-test which measured ability in multiplication and division. Experimental subjects practiced for two or three periods on successive days; at the end of the training, the post-test was given to the experimental student and his control. Twelve of the 14 experimental subjects showed greater gains than did their controls; one showed less gain. On the whole, the experimental group was significantly better at the 1 percent level. Keislar found a *rho* of .83 between the

errors made during instruction and a post-test with the experimental subjects. He also noted a wide range of individual differences, even among individuals of similar intelligence and reading ability. The error graph indicated several weaknesses in the item programming. He concludes that a teaching machine can promote understanding of arithmetical concepts. It might be noted that the controls received no specific instruction whatsoever.

Kendler, Howard. "Teaching Machines and Psychological Theory." In *Automatic Teaching: The State of the Art*, edited by Eugene Galanter. New York: John Wiley & Sons, 1959.

Kendler commends Skinner's advocacy of the teaching machine as an educational instrument as most reasonable. The machine can be a powerful learning tool because of feedback and flexible rate of presentation. Kendler feels that it would be useful to distinguish between the teaching machine as an educational machine, and as an expression of Skinner's theoretical position in the psychology of learning. Kendler is interested in the theoretical aspects of the use of teaching machines, especially in the S-R Mediational Theory. Basic to programming is an understanding of the principles that operate in the student's ability to generate implicit responses that function as cues for overt behavior. He mentions recent work in problem solving and such language behavior as (a) language ability, (b) concept formation and concept utilization, (c) transfer, (d) individual differences, and (e) criterion of learning—all of which must be considered in the programming of teaching machines.

Klass, Philip. "Video-Sonics Cuts Production Defects." *Aviation Week*, January 4, 1960.

Video-Sonics is essentially a variable rate guidance device using a visual display from 35mm slides and audio instructions from a prerecorded magnetic tape. Careful analysis of a manufacturing task, in this case electronic chassis assembly, was programmed into the video-sonic device. The operator is guided through each complex assembly task. The operator can slow or stop the video-sonic guidance. There is no feedback as in a teaching machine situation.

Video-Sonics made a startling increase in efficiency on the production line. Production employee errors dropped 99 percent in 10 months. Production improved from 60 percent of work standard to 90-100 percent. Also greatly aided were the training of new operators and making changes in production. In one system, test operation time was reduced 95 percent. Production language can easily be changed. Hughes Aircraft, the developer, will make Video-Sonics available to the Air Force but not to other manufacturers.

Komoski, Kenneth P. *Origin of Collegiate School Automated Teaching Project.* Unpublished Report. Collegiate School, 241 West 77th Street, New York 24, February 1960.

A two-year project was started in November 1959 with a grant from The Fund for the Advancement of Education. Rheem Califone has supplied 15 write-in machines and IBM has made a computer laboratory available for analysis of data.

Programming is in progress in the following areas:

1. *French Spelling* for the sixth and seventh grades to supplement the direct

(conversation) method. "Preliminary studies seem to indicate that this program is approximately twice as effective as other spelling methods." (p. 2)

2. *Pre-Verbal Number Concepts.*

3. *Elementary Arithmetic;* a revision of Susan Meyer's program.

4. *Sets, Functions, and Relations* for high school as recommended by the College Entrance Examination Board Commission on Mathematics—this program has been put on programmed texts available for 30 eighth graders (experimental copies $5).

5. *Elementary Statistics* programmed text written by Homme, Glaser, Stelter and Evans will be used on twelfth graders.

6. *Remedial Spelling* for high school students based on 100 words commonly misspelled by college freshmen.

Future plans of the project include further programming, experimentation, and teacher's institutes (Summer of 1961).

Little, J. K. "Results of Use of Machines for Testing and for Drill Upon Learning in Educational Psychology." *Journal of Experimental Education* 3:45-49, 1934.*

In this study, comparison was made between two of Pressey's multiple-choice teaching machines, using control groups. The subject matter was educational psychology and all students were enrolled in regular classes in educational psychology. The control group was paired by intelligence and pre-test subject matter scores. The first device was similar to the one reported by Pressey in 1926. This was a small multiple-choice type of teaching machine in which the student answered objective questions and kept on working until he had mastered all of the questions.

The second device was really not a true teaching machine by many definitions. It was an automatic scoring machine which scored objective examinations immediately after they were taken and errors were marked. The instructor could glance at the counters on the machine and see the items that were most frequently missed. The instructor then conducted a discussion in class on items which the majority of the members of the class did not understand.

Both the test machine and the drill machine groups did better than the control groups. On a 200-item multiple-choice test, the difference between medians of the experimental group and their controls was 9 points, the probable error of the difference was 1.92, while the ratio of the difference divided by the probable error was 4.69. For the drill machine group the difference between medians of the experimental drill machine group and their matched controls was 17 points, the probable error of the difference was 2.43, and the ratio of the difference divided by the probable error was 7.26. One of the most interesting findings was that the slower students apparently profited most from use of the teaching machines. This is shown by a quartile comparison: at Q/1 the drill group was 19 points above the Q/1 of the control group, whereas the drill group at Q/3 was only five points above the corresponding control group. It might be noted that Q/1 of the drill group was 7 points above the median for the control group.

Little stated that this was the first systematic use of teaching machines in regular university classes, and felt that it demonstrated the feasibility of using mechanical aids in classes in education.

Lumsdaine, A. A. *Possibilities and Implications of Automated Teaching Methods.* Paper read at the American Psychological Association, Washington, D. C., August 1958; cited by Carr, 1959.

Convention abstracts state that A. A. Lumsdaine was chairman of a symposium on "The Automation of Teaching." The participants were B. F. Skinner, Ernest Rothkopf, N. A. Crowder, and S. L. Pressey, with David Zeaman as discussant.

Lumsdaine, A. A. "Partial and More Complete Automation of Teaching in Group and Individual Learning Situations." In *Automatic Teaching: The State of the Art,* edited by Eugene Galanter. New York: John Wiley & Sons, 1959.

Lumsdaine was concerned with machines which had at least these three features: (1) student activity, (2) presentation of material that can be made contingent upon student response, (3) knowledge of results with minimum delay leading the student to correct errors. He mentioned characteristics common to both group instruction devices and individual teaching machines: (1) controlled sequencing, (2) prior programming, (3) provision for active responses, and (4) correction feedback.

Lumsdaine states that many of the factors involving programming need experimental investigation, especially (1) item sequencing, (2) versatility and range of stimulus material, (3) response repertoire (recognition versus constructed responding), (4) degree of mechanization for response assessment, (5) characteristics of feedback, (6) size or difficulty of steps, (7) kind and variability of explanatory exposition preceding questions or following responses, and (8) use of cues or crutches. Some empirical investigations were used to illustrate these points.

Lumsdaine, A. A. *Response Cuing and Size-of-Step in Automated Learning Programs.* Paper presented in the Symposium on Research Issues in the Study of Human Learning Raised by Developments in Automated Teaching, American Psychological Association Annual Convention, Cincinnati, September 1959.

Lumsdaine gives an overview of the teaching machine field, with illustrations of numerous devices. He outlines the common features of various teaching machines, and the major issues involved in their application, namely:

1. What is the role of automated teaching devices in the instructional plan?

2. What are some of the factors involved, such as the form of student response, display of capabilities, and type of feedback?

3. What are the major factors in the programming of material, such as size of step, cuing, and logical organization of program?

In response to some authorities who feel that the automated teaching machine movement consists largely of constructing the correct program he disagrees and feels that the issue is much broader.

Lumsdaine states that the American Institute for Research with Air Force Office of Scientific Research support is beginning a two-year program related to automated teaching which will investigate such factors as size of step and cuing. Some of the problems involved in size of step are the size of the response (should it be one letter, a whole sentence, or a phrase?) How big should the frame size be? (Should the stimulus item be only a sentence, or

two, or a number of paragraphs?) What of the logic of program sequencing?

Some of the problems involved under cuing concern the cues which are desirable for specific behavioral outcomes, for different stages of learning, and for different characteristics of learners. Can effective cue strength be contextual? Are semantic cues as valuable as physical variation cues?

Lumsdaine reports that some of these questions are also being investigated by Matthew Israel at Harvard, and E. Z. Rothkopf at Bell Telephone Laboratories. He mentions several devices not mentioned elsewhere in this bibliography. One is the Bell Device designed by Oliver Holt of Bell Telephone Laboratories, a simple write-in type of machine in which the programmed material is presented on a paper roll. The student writes directly on the roll, then turns it to the next frame to show the answer. After this the roll may be turned to the next item.

Another machine mentioned is the Skinner-Zeaman Arithmetic Machine. The student responds by moving sliders and dials to "set in" the answer to the numerical problems.

Another experimental device is Rothkopf's Polymath, which allows for an extensive response repertoire permitting both multiple-choice and construction of answers using alphabet letters or numerals through the use of sliders. An additional unique feature of the Polymath is the use of a printed circuit display sheet in which the student can respond to two-dimensional positioning. For example, a student can trace a route on a map using a stylus with feedback throughout the training operation.

Lumsdaine, A. A. "Teaching Machines and Self-Instructional Materials." *Audiovisual Communication Review*, Vol. 7, No. 3, 163-181, Summer 1959.

An overview of the development of teaching machines with a number of excellent illustrations. Of unique interest is the reference to Maccoby and Sheffield's "automatic projector" which is an individual motion picture projector that shows short (5 minutes) film loops for visual and audio guidance in a training task such as electronic equipment maintenance. The automated projector does not have feedback, but selecting segments of it can yield a variable program.

Lumsdaine, A. A., and Glaser, Robert, editors. *Teaching Machines and Programmed Learning: A Source Book.* Washington, D. C.: Department of Audiovisual Instruction, National Education Association, 1960 (in press).

This book is a collection of key papers on teaching machines and self-instructional materials.

Annotations in this bibliography appearing in greater detail in Lumsdaine and Glaser's book are marked with an asterisk (*).

Mager, R. F. *Preliminary Studies in Automated Teaching.* Proceedings of the Institute of Radio Engineers, October 1959, p. 1790.

In this introductory article to the field of teaching machines Mager cites some of the studies reported in this bibliography. He describes them as "dramatically effective," predicting that electronics people will be intimately associated with them in both developing and teaching the subject of electronics.

Mayer, S. R., and Westfield, R. L. *A Field Try-Out of a Teaching Machine for the Training of SAGE Operations.* Technical Memorandum, OAL-TM-58-16, Operational Applications Laboratory, Air

Force Cambridge Research Center, Bedford, Mass., October 1958.

This article describes a field try-out of the Subject Matter Trainer as an on-the-job proficiency-maintaining device, at the New York Air Defense Sector of the SAGE system. Intercept directors and track monitors were trained in knowledge of components critical to development and maintenance of operator proficiency. In an alternate group study using workbook methods, both groups made gains; some favored the workbook group. Opinion and attitude survey results were favorable and the authors concluded that such a device could be recommended for use in job knowledge training in field situations.

Mellan, Ibert. "Teaching and Educational Inventions." *Journal of Experimental Education* 4:291-300, 1936.*

The author has searched the literature of the U. S. Patent Office and found that from 1809 to 1935 between 500 and 600 patents were issued on the subjects of teaching and education (patent numbers are listed). Many were concerned with "visual instruction." The article classifies dozens of patent titles and numbers according to educational subject matter, for example, reading, arithmetic and others. Several large categories such as "educational devices" and "educational appliance" contain lists of patent numbers.

Meyer, Susan. "A Program in Elementary Arithmetic: Present and Future." In *Automatic Teaching: The State of the Art*, edited by Eugene Galanter. New York: John Wiley & Sons, 1959.

This is an early report of an investigation by Meyer using a slider type machine to teach arithmetic to elementary school children. The machine was built by IBM. Other references to the slider type machine developed in cooperation with Skinner are made by Edwards and by Skinner (1958).

Meyer used 26 children attending grades one through six. The study was more of an investigation procedure than a controlled experiment. Meyer found that a fairly large minority of second grade children had difficulty in matching answers correctly. Hence, this device (and others which use matching of correct answers as a measure of knowledge of results) is considered not too successful at the second grade and most probably at grades just above or just below. She also found that the prompts were not always obvious to a child. Sometimes the child must learn the prompts. Meyer was concerned with the problem of understanding; to teach this, she used Skinner's rich context idea of number concepts. This meant that multiplication, division, and addition of simple concepts (lower numbers) were taught before progressing on to higher numbers. She noted that in the school where she was conducting the investigation the children were chanting the counting of fives up to 100 before she had given them the concept of "nine" and the various combinations leading up to the concept "nine."

Miller, Robert B. *Psychological Considerations for the Design of Training Equipment.* WADC Technical Report—54-563, Air Research and Development Command, Wright-Patterson Air Force Base, Ohio, December 1954 (American Institute for Research, Pittsburgh).

This 139-page report was prepared under a Human Engineering Factors Project administered by the psychology branch of the Aero-Medical Laboratory at Wright Air Development Center un-

der Gordon Eckstand. The report covers a wide range of topics—principles of learning and transfer of training, physical simulation, knowledge of results and scoring, proficiency measurements, and an outline of steps in designing training devices.

Of interest is the comparison of learning versus action feedback. Learning feedback is defined as that which modifies the next response after a period of time, while action feedback is defined as an instantaneous feedback which modifies a continuing action. The difference seems to be the use of memory.

Miller makes an interesting distinction also between operational and artificial feedback. Artificial feedback is feedback which is found only in training situations, that is, the instructor cautions the student, or a click is heard when on target. Miller holds that the use of artificial cues is not justified. For example, making the target red aided learning, but when the red was removed, the performance dropped back to the level of the control group which had equal practice without the artificial cue. Miller found that natural cues predominated over symbolic cues unless the student was trained otherwise. Learning to disregard misleading cues is also important and training is helpful here. If two cues are equally relevant, learning to use one does not mean that the other one is also learned. Caution should be exercised that spurious cues are not learned. Dramatizing cues such as emotional music played during a training movie may increase motivation and interest, but do not aid learning *per se*.

Miller states that a difficulty ratio in training devices should provide for approximately 50 percent success with progress towards the end.

Morton, F. Rand. *The Language Laboratory as a Teaching Machine.* Paper presented at the Language Laboratory Conference, Indiana University, January 1960.

This 85-page article delves into the psychological principles of language instruction. Skinner is prominently mentioned and the author points out the teaching machine aspects of a language laboratory.

Pask, G. "Report on Symposium Papers at Conference on Automata Held in Teddingham, England." *Automation Progress,* Vol. 4, No. 2, circa 1957; cited by Coulson and Silberman, 1959.

Pask, G. *Teaching Machines.* Solatron Electronics Group Ltd., Namur, Belgium, Proceedings of the 2nd Congress, International Association for Cybernetics, September, 1958.

Pask, Gordon. "The Self-Organizing Teacher." *Automated Teaching Bulletin,* Vol. 1, No. 2, December 1959.

A teaching machine must have some similarity to the man that it teaches, that is, it must be able to carry on a conversation or to interact. In a practical sense, this means a man interacting with a self-organizing computer. Pask feels that this man-machine interaction will achieve a stability that neither one would obtain alone. In this system of two self-organizing systems, one at least can be accurately analyzed (the machine) and thus new insights be gained in the learning phenomena. Hence a self-organizing computer which is allowed to build its own mode of an efficient tutor, based on the man's learning responses, should prove an effective device for training and understanding learning.

Peterson, J. C. "A New Device for Teaching, Testing, and Research on Learning." *Transactions of the Kansas Academy of Science* 33:41-47, 1930.

This reference was taken from the Angell 1948 study. It describes two procedures for giving immediate knowledge of results. The first device was an envelope which contained several layers of cardboard. When a pin was punched through several selector holes it was possible to record the response, and knowledge of results was given to the testee depending on whether or not the pin went through the envelope. This is believed to be the forerunner of Pressey's punchboard.

The second device is a small answer card which has five spots of chemical after each number. The testee responds to a multiple-choice question by marking a special ink on top of the spot. If the spot is the incorrect answer the ink shows a red mark; if it is the correct answer, the spot turns blue or a definite dark color. Pressey, in personal correspondence, later referred to this as the Chemo card. This card was to be manufactured by the Crafting Manufacturing Company, 1615 Collamar Avenue, Cleveland 10, Ohio. The stylus used in marking these Chemo cards is a cheap fountain pen filled with a special non-expensive ink. Pressey seemed rather interested in the Chemo card and suggested that "apparently a number of fairly well known schemes of secret ink may so serve, and your chemistry department might help you out."

Porter, Douglas. "A Critical Review of a Portion of the Literature on Teaching Devices." *Harvard Educational Review*, Vol. 27, No. 2: 126-47, 1957.*

This is a fairly comprehensive review of the literature which includes many immediate knowledge-of-results devices such as those covered in major articles by Skinner and Pressey. Also reviewed are such devices as the tachistoscope, language records, and such reading devices as pacers and films. Numerous audiovisual studies are reviewed, including two interesting studies on the use of a typewriter in elementary schools. Porter states that "over 90 percent of the teaching devices in use probably are the stimulus type of teaching aid. Such devices provide a student with information and may motivate activity, but stimulus devices do not provide for the rehearsal or practice of behavioral responses appropriate to the basic skill areas of schooling." (p. 140) In other words, most audiovisual devices are not teaching machines.

Porter concludes: "It may be that increased use of stimulus-response devices which do provide for practice of skills will place mechanical teaching devices in a more prominent classroom role."

Porter, Douglas. "Teaching Machines." *Harvard Graduate School of Education Bulletin*, Vol. 3, No. 1, March 1958.*

In this article Porter discusses theories and programming of teaching machines. He is quite concerned over the problem of reinforcement, and states several principles to be applied: (1) reinforcement must be immediate, (2) reinforcement must be precisely contingent upon performance, (3) a sufficient number of reinforcements must be given. In an example he states that a school child learning to spell 10 words probably has to be reinforced several times for responses to four or five elements in each word. This means that each individual in a class of 30 has

to be reinforced, roughly, 150 times in a 20-minute period. To do this job of instruction, a teacher would have to be capable of reinforcing his class a total of 4500 times or about 225 times per minute. Quite obviously, this is impossible.

Porter states that the three essential operating characteristics of a teaching machine are: (1) they present the problem materials one item at a time, (2) they provide some means by which the student can indicate or record his solution to each item, and (3) they immediately confirm the correctness of his response.

In programming materials at Harvard, several techniques are being utilized: (1) the content to be taught is broken down into a large number of steps, (2) successive steps in the lesson are prompted by preceding items or by hints provided explicitly for that purpose, (3) prompts and hints are gradually "vanished" or removed so that by the time a student has completed a lesson, he is "on his own." Porter points out that the principles of programming are not "rote learning" or "drill," for rote materials presented for memorization are not accompanied by prompts; hence, a good deal of guessing and wrong responses usually ensue. In fact, rote learning usually implies that the material is unorganized.

Porter concludes that programs of educational content must be prepared and tried out on machines. This is a difficult and long task that has barely been started; actually, it will never be finished.

Porter, Douglas. *A Report on Instructional Devices in Foreign Language Teaching.* Prepared for The International Training and Research Program of the Ford Foundation, October 1, 1958 (19 p., mimeo.); cited by Darby, 1959.*

"Specific recommendations for the implementing of a language package for self-instruction in Russian. Considers research versus teaching uses of teaching machines along with some preliminary notions about programming language materials." (from Darby)

Porter, Douglas. "Some Effects of Year-Long Teaching Machine Instruction." In *Automatic Teaching: The State of the Art,* edited by Eugene Galanter. New York: John Wiley & Sons, 1959.

In the academic year 1957-58 an experiment was carried out on the teaching of spelling to elementary school children under the sponsorship of the U. S. Office of Education. Porter used a simple write-in type of teaching machine. The materials were printed on eight-inch-wide duplicating paper. On the first line of the sheet a question was printed which required the student to respond directly on the sheet through an open window in the machine. The student then moved a lever which rolled the paper up one line; this placed the question and the student's written answer under a sheet of glass exposed with the correct answer so that he could score himself right or wrong. The lever was then moved to bring the next item into view. The chief functions of the machine were to expose one item at a time and to prevent cheating.

An interesting aspect of the entire program was that no spoken instruction was given to students. Teaching materials paralleled standard lessons in textbooks which were used by the control group as closely as possible. The words taught were exactly the same as those received by the control group.

The teaching machine program attempted the following sequence of responses:

1. Identification of spelling words in a meaningful sense context.
2. Matching the correct word or given definition.
3. Matching several words on the basis of letter structure.
4. Writing missing letters in words presented in sentence context.

Twenty-two weeks of a normal 34-week program of spelling instruction were given on both the sixth and the second grade levels using the teaching machine. Results were measured on standardized achievement test scores. These showed the experimental group to be significantly superior.

Porter reported that there was essentially no relationship between intelligence scores and achievement in the experimental group, but there was a significant positive relationship in the control group. Porter's experiment seemed to indicate that this type of instruction is particularly good for the lower IQ groups. No relationships existed in either group with respect to sex or whether or not students liked the instructional method. To check on the "novelty" factor of the new instructional process, Porter compared first-half and second-half machine scores; no differences were apparent.

In the sixth grade experimental group a positive relationship existed between the number of responses per lesson required of subjects and subsequent achievement, but no relationship existed between the number of errors per lesson and achievement. In the sixth grade group, lesson materials were available on a week-by-week basis; yet the experimental group spent only about one-fourth as much time studying as did the control group.

In the second grade group, materials were available on an *ad libitum* basis for 12 weeks. During this time the spread of materials extended to nine lessons; in other words, some students had a high rate of response when released from the more strait-laced type of curriculum.

More specific statistical data were given by Porter in a "hand-out" which stated that the mean student achievement during the year in grade equivalent scores showed that the experimental group gained 1.42 years while the control group gained .90 years. A sign test showed this to be significant at the .01 level. Statistical data for the second grade showed that the experimental group gained .80 years while the control group gained 1.10 years. (U test, .005). A second method of rating second graders was letter position scores in which each letter was scored. In this the experimental group gained 65.6 while the control group gained 37.8 (U test, .001). In an interesting side light Porter found that 20 percent of the second graders and 10 percent of the sixth graders could not match their answers with the answers given in the machine.

Pressey, Sidney L. "A Simple Apparatus Which Gives Tests and Scores—and Teaches." *School and Society* 23:373-76, 1926.*

This is the first major published article in the field of teaching machines. Even though the article was published in 1926, it is interesting to note that apparently Pressey had the idea of teaching machines some time before. He states: "For a number of years the

writer had it in mind that a simple machine for automatic testing of intelligence or information was entirely within the realm of possibility. The modern objective test . . . suggests such a development." (p. 173)

Pressey's original machine, which was about the size of a small portable typewriter, presented multiple-choice questions on a drum. The student responded by pushing one of four buttons. He was not permitted to proceed to the next item until the right answer button was pressed. The machine kept an error count. By shifting a lever the machine could be placed in test position in which the student received no knowledge of results.

Pressey, Sidney L. "A Machine for Automatic Teaching and Drill Material." *School and Society* 25:549-52, 1927.*

In this article Pressey described a modification of the machine mentioned in his 1926 article. The machine works in such a way that an item which has been answered correctly twice is automatically eliminated from the series. Hence the subject continues to work the items which remain on the drum until all have been answered successfully at least twice, at which time the machine issues a "coupon," indicating mastery. Pressey mentioned the negative aspect of the law of effect, stating that a student is penalized for making wrong responses by having to answer the item again. The positive value of the law of effect is the rewarding factor of having the item eliminated. Since the learner is instantly informed of the correctness of the response, and questions eliminated as soon as they are mastered, wasteful overlearning is avoided.

Pressey states that he has in mind an arithmetic machine which will use an adding machine type keyboard and perforated cards or paper tape.

Pressey, Sidney L. "A Third and Fourth Contribution Toward the Coming 'Industrial Revolution' in Education." *School and Society* 36:668-72, 1932.*

In this article Pressey describes one device with which Little later experimented (see Little, 1934). The device was more an automatic scoring machine than a true teaching machine. Students punched their answers on special answer sheets. As they finished the quiz, they brought the answer to the instructor at the front of the room, who then placed the scoring sheet inside the automatic scoring device. This immediately marked errors and totaled them, and recorded an error count by item. At the end of the period when all papers were corrected, the instructor could look at the item tallies on the machine and immediately know which item needed further discussion.

Pressey, Sidney L. "Development and Appraisal of Devices Providing Immediate Automatic Scoring of Objective Tests and Concomitant Self-Instruction." *The Journal of Psychology* 29:417-47, 1950.*

This is Pressey's major study in the field of teaching machines. It is also one of the largest teaching machine studies to date and is centered largely on the use of the punchboard device. Much of the work reported here was done at the Ohio State University Research Foundation under subvention of the Special Devices Center of the Office of Naval Research (reported to the ONR in 1949).

The value to the student of immediate scoring and feedback is important, for he knows at once exactly which questions are wrong, not just that he scored a certain percentage on the total

test. In other words, the device not only tests, it also teaches.

Pressey describes his punchboard as being about the size of a 3x5 card, one-half inch thick. On each face the punchboard has two columns each of four rows of ⅛-inch holes. The rows of four holes are numbered from one to 30. The key sheet inside the punchboard has holes only opposite the right answer for that particular test. Test questions are usually presented on a mimeographed sheet but may be given orally, on a blackboard, or projected on the screen.

The testee takes the test by punching a pencil through the punchboard; this breaks a hole in an answer slip of paper. If the hole punched indicates the correct answer, the pencil goes deep into the punchboard and makes a large hole in the answer sheet. And if it is the wrong answer, the pencil point breaks a small hole in the paper but does not go deeply. Hence the student has knowledge of results by the depth to which his pencil can be inserted into a given hole. In this way, each part of each item yields immediate knowledge of results.

Pressey decided to use three types of materials on college students: (1) Russian vocabulary, because it was more interesting and more valuable than nonsense syllables; (2) hard English vocabulary, because it represented material that was highly meaningful but without any organization or structure; and (3) subject matter from two courses in psychology, because it provided material that was highly organized into a systematic program of instruction. The major effort was to find the value of self-instructional materials that are sufficiently extensive to cover regular college courses.

Among Pressey's major conclusions are:

1. Punchboards are a simple way to combine the taking of a test, scoring it, informing students of their errors and giving them guidance in finding the right answer.

2. Punchboards as used in this study did transform test-taking into a form of systematically directed self-instruction.

3. When self-instructional tests are used systematically in college courses, gains are substantial and sufficiently generalized to improve understanding of the subject as a whole.

4. The total project has shown that there are various promising means of automatic scoring and self-instruction.

He mentions his interest in trying a "chemo card" and other devices also reported in his 1926 and 1927 articles. "The value of such devices, and the need for carefully planned methods for their use, if those values are to be realized, both seem clear," he writes.

Pressey, Sidney L. "Certain Major Psycho-Educational Issues Appearing in the Conference on Teaching Machines." In *Automatic Teaching: The State of the Art*, edited by Eugene Galanter. New York: John Wiley & Sons, 1959.

This paper was prepared for inclusion in Galanter's book on teaching machines recently off the press. Pressey stresses the fact that much relevant research has been done in educational psychology that is often overlooked by teaching machine researchers. He is also concerned with the problem of using teaching machines as an "aid to" or a "replacement of" regular instruction.

Pressey disagrees with what he calls the "short-easy-step-program type of

thinking" exemplified by Skinner and his followers. He cites such instances as the Ford Foundation report, *They Went to College Early,* which showed that bright students who skipped up to two years of high school did better work than most college students. He concluded with a plea for more experimentation with control groups and practical applications.

Price, George R. "The Teaching Machine." *Think,* Vol. 25, No. 3, March 1959.

In a popular introductory article, Price discusses Skinner's principle of "shaping" and the teaching machines used by Porter and Holland at Harvard. Price calls them "an important new invention."

Ramo, Simon. "A New Technique of Education." *Engineering and Science* 21: 17-22, October, 1957.*

(Ramo published an article under the same title in the *Institute of Radio Engineers, Transactions on Education,* E-1:37-42, in 1958.)

Ramo holds that our technological growth is far in advance of our educational system. One way of integrating the two, he feels, will be the use of teaching machines in regular classrooms. He thinks that a typical school day will contain some time with a machine for each student. Possibly the student will view a picture and give his reactions to questions; these will be electronically reported to the teacher, and then to a master computer "memory." He feels that machines could help students in memorizing material, and would take much of the drudgery out of it by making it more interesting and efficient. Machines use feedback, repetition, and self-selection of repetitive questions missed. This is not to claim that all education could or should be received from machines. He suggests that chemistry could be taught by a film feedback machine; other devices could teach English by assisting in the comprehension of literature and knowledge of mechanics; foreign language might use a tape playback device.

He envisions the creation of a substantial new industry in the United States concerned with developing teaching machines, related educational motion pictures, and other memory data used by the machines. Such an industry would employ experts in education, subject matter and engineering. All this would be done in close contact with regular school staffs. He suggests that there might be a new profession made up of "teaching engineers," individuals who would be concerned with the educational process and the design of machines. The creation of material for the machines would move partly out of education into industry. From the standpoint of the student, the machines could mean less homework, leaving evenings free for culture and recreation. He believes that the teacher is becoming too "expensive" for routine tasks.

Rath, Gustave; Anderson, Nancy; and Brainard, R. C. "The IBM Research Center Teaching Machine Project." In *Automatic Teaching: The State of the Art,* edited by Eugene Galanter. New York: John Wiley & Sons, 1959.

This paper is primarily a discussion of binary arithmetic, the most interesting section, from a teaching machine standpoint, being a description of the use of an IBM 650 general purpose digital computer to simulate a teaching machine. This computer used a typewriter input and output. The subject matter

was the teaching of binary arithmetic. Psychological principles programmed into the teaching machine computer were:

1. The student was required to construct his own answers by typing them into the machine.

2. The machine corrects the answer unit by unit, or digit by digit.

3. Errors are eliminated in some cases, as when the student tries to make the answer too long. Here the machine says "Right" before an error can be typed.

4. The machine allows for individual differences in skill level and rate. In other words, if the student is making a large number of errors, the machine will go back and repeat steps. The number of errors made determines how far the machine will skip back for repetition.

Knowledge of results is provided automatically as the student continues working through the program. If the student makes an error, the machine stops. Knowledge of results is given, character by character. The computer also allows the student to skip problems if no errors are made. The skipping of problems is optional with the student. The IBM 650 has the capacity to handle a number of input stations of this type. A cost advantage is seen in using a 650 computer for research purposes, since it is much cheaper to program the characteristics of a teaching machine into a computer than to build a similar device as a teaching machine. If it is anticipated that the characteristics are likely to be changed or should be changed as part of a research project, perhaps it would be actually cheaper to use the 650 for research. But as a regular training device, the cost of the IBM 650 would be prohibitive.

Renner, Inc. *Inexpensive Missile Training—A New Approach.* Paper presented at the U. S. Navy Guided Missile Training Symposium, Naval Ordnance Laboratory, Whiteoak, Maryland, March 1958.

In this paper Renner describes and discusses training possibilities of the "study card" set, also known as the "trainer-tester." Another reference to this type of training aid is listed under Van Valkenburgh, Nooger and Neville who hold the basic patent. Renner claims that the study card set provides realistic and accurate synthetic simulation of problems and situations encountered in the operation and maintenance of real equipment, a technique referred to as paper simulation. Features of the study card set are well thought-out problems; step-by-step testing, as well as training; immediate reinforcement; active learning; and self scoring.

The study card sets or "trainer-testers" have been applied chiefly to electronic trouble shooting. However, reference is made to its use in a 164-exercise test set on the Navy's guided missile, Terrier. For electronics trouble shooting, each student receives a schematic diagram of the circuit, a sheet of basic instructions and a corresponding pictorial wiring diagram. He also receives the specific drill sheets or exercise sheets. On each sheet there is a problem expressed as "only high-pitched squeal comes out of the speaker." The student then attempts to locate the trouble by looking at the diagram, selecting a check point, and simulating the check by erasing a silver overlay on his exercise sheet. When he erases the silver overlay he is informed of the informa-

tion he would have obtained had he actually made a check at this point on the real equipment.

In addition to various types of tests, such as resistance across individual parts and power transformer checks, there is a section of the exercise sheet which tells results of parts replacement. When the student is able to pinpoint the exact part replacement, the problem is solved. A typical trouble-shooting problem contains several hundred check points and more than 50-part replacement items. The more efficient trouble shooter would attempt to arrive at the difficulty with a minimum of check tests and part replacements. Once the student has simulated a part replacement by erasing the silver overlay, he is informed of the correctness of this maneuver, but his error is allowed to stand because he cannot replace the silver overlay. This equipment provides for a computation of the total number of tests and attempted solutions, but does not provide for any working order in solving the problem.

Technical personnel agreed that the correction of an equipment failure is approximately 90 percent mental and 10 percent physical labor.

The reported cost of 1200 sets (a total of 250,000 sheets) used in the Terrier Missile Tests was approximately ".30 cents per sheet," possibly a typographical error. Since this cost included research, engineering, liaison, gathering of technical data, preparation of art work, preparation of reducible copy and printing, the ".30 cents per sheet" may mean 30 cents per sheet, a more realistic figure of $75,000 for the program rather than $753, if the price were a third of a cent per sheet. A set consisted of 164 different exercise sheets and 45 reference sheets which included schematic wiring diagrams and equipment photographs.

Root, R. T. *An Annotated Bibliography of Research on Training Aids and Training Devices.* Staff Memorandum, Training Methods Division, HumRRO, George Washington University, Washington, D. C., August 1957; cited by Darby, 1959.

Rothkopf, Ernst Z. *Research Problems in the Design of Materials and Devices for Automated Learning.* Paper read at the American Psychological Association, Washington, D. C., August 1958; cited by Coulson and Silberman, 1959.*

Rothkopf, Ernst Z. *Heuristic Discussions of Psychological Bases for the Conduct of Training by Automatic Devices: I. A Functional Diagram and an Approach to Research.* Unpublished paper; cited by Darby, 1959.*

"Describes possible divisions of function between various components of an automatic teaching device. It is suggested that the ultimate design of a teaching device be shaped up through a series of successive approximations by simulating device functions in a mock-up design." (from Darby)

Schutz, Richard E. *Progress and Preparation of Automated Instructional Material and Criterion Measures.* Symposium on Automated Teaching, Western Psychological Association Annual Meeting, San Diego, April 1959.

Schutz reports the results of approximately one year of an elementary arithmetic program developed according to "Skinnerian principles." Although no direct rules on programming are reported, it is stated that the investigator can successively approximate a refined instructional sequence, (that is, learning by doing). Usual paper and pencil tests are not considered applicable for automated instruction programming because "we do not have direct knowledge

of the student's work through the program." This handout contained a classification of items similar to that found in Gilbert, 1958.

Sevrin, D. G. "Appraisal of Special Tests and Procedures used with Self-Scoring Instructional Testing Devices." *Abstracts of Doctoral Dissertations,* No. 65, Ohio State University Press, 1955.

This is an interesting study of methods of programming material for multiple-choice type questions. Sevrin investigated several types of practice tests, including four-choice, three-choice, and two-choice problems, as well as a new type called the four-pair and two-pair item, and items involving application and judgment.

For example, a four-pair test contained one item consisting of four parts, each of which contained a Russian word and an English word. Three of the four paired choices were correct and one of the pairs was incorrect. The object appeared to be to present as many correct associations and as much information per item as possible. In fact, the author states that the four-pair test was indeed planned to give as many right associations as possible. In the two-pair test each item consisted of, first, a Russian word followed by an English word lettered A and an English word lettered B; this was followed by a Russian word. The object of the test was to match the final Russian word with the correct English word.

Sevrin used 2000 students from Ohio State University and Otterbein College.

Of the results of practice tests comparing four-, three-, and two-choice items, Sevrin says: "The more wrong answers a test question has the more trouble it is to make and the more time it takes to give a score." In his study which compared four-choice and two-choice multiple problems he found that four-choice problems yielded a greater number of errors but when an end recall test was used to measure learning, there was no significant difference between the means. This was true on both Russian vocabulary and English vocabulary subject matter. He concludes that if learning is the first consideration, no more than two choices seem needed in a test; if discrimination is the main reason for giving a test, more choices appear desirable.

Sevrin reports the results of his comparison of the four-pair versus four-choice item tests as follows: "Mean number of errors on the end test was seven less after the four-pair than after the four-choice multiple test with the punchboard. This difference is statistically significant at well above the 1 percent level of confidence."

In comparing the two-pair versus two-choice practice tests he states: "Two-pair Russian and English practice tests yielded fewer errors on end tests and so presumably more learning than on two-choice practice tests; the difference was significant at the 5 percent level of confidence." He concludes that paired tests can be made satisfactorily only with certain types of material, such as vocabulary.

Sevrin also compared the punchboard with other methods of study. The first group was a class which studied a list of 30 naval terms and their meanings for 30 minutes. A second class studied the list of naval terms for 15 minutes and then studied for 15 minutes a practice test with answers marked. A third group studied the list for 15 minutes and then took the practice test using the punch-

board for 15 minutes. The groups were given an immediate after-test which required definition of the naval terms; a week later, they wrote as many naval terms as they could remember and took the end test again. There was only one difference which was statistically significant at the 5 percent level. This was in favor of the punchboard over the study-only group on naval vocabulary definitions written in after a week's delay.

Sevrin also investigated the benefits derived from repetition of practice tests. He gave both immediate and spaced repetition of the same test and found that repetition (either spaced or immediate) did not yield a statistically signficant difference when the test was taken only once.

In conclusion, the unique factor of this study is the finding that a two-choice test causes as much learning as a three-choice or four-choice test. Sevrin also found that two-pair and four-pair practice tests aid learning more than do two-choice or four-choice practice tests.

Silberman, Harry F. *Introductory Description of Teaching Machines.* Abstracts, Symposium on Automated Teaching, Western Psychological Association, San Diego, 1959.

Silberman states that automated teaching devices consist of four units: (1) an input unit, (2) an output unit, (3) a storage unit, and (4) a control unit. These devices differ in complexity from digital computers to paper-and-pencil devices. The goals vary from rote memory to complex decision-making skills. Inputs would include audio and visual inputs, verbal inputs and motor inputs. Outputs would include audio and visual display, and knowledge of results in the form of information, food, coins, and other reinforcers. Stored information concerning the behavioral data differs from machine to machine. Machines also differ in type of problem material, accessibility of materials, and instantaneous storage capacity. Control units may determine the selection of materials as a complex function of the student's performance. At the simplest level, presentation is made merely of a series of pre-stored items. Performance may be evaluated as right or wrong, or in more complex ways.

Silberman, Harry F. "The Automation of Teaching." In *Behavioral Science,* 1960 (in press).

The article discusses the desirability of using computer with teaching machines. One of the important values mentioned is that the computer can be programmed to modify its own instructions in response to student performance. An interesting and complex diagram on "Functional Steps in Problem Selection Program" shows the many factors and choices a computer can make before selecting a given item for the student.

Skinner, B. F. "The Science of Learning and the Art of Teaching." *The Harvard Educational Review,* Vol. 24, No. 2, Spring 1954.*

In this article Skinner lays the basis for his later development of teaching machines. He places heavy emphasis on the control of behavior by proper use of reinforcement, stating: "Perhaps the most serious criticism of the current classroom is the relative infrequency of reinforcement." (p. 91) Later he points out that perhaps a very slight reinforcement may be tremendously effective in controlling behavior if it is wisely used. He notes that the teacher cannot possibly give adequate amounts of rein-

forcement, a fact that would be true even if a single teacher devoted all her time to a single child. "If a teacher is to take advantage of recent advances in the study of learning she must have the help of mechanical devices." (p.95)

The article describes the arithmetic machine which is still under development at this time, stating that the manipulation of the device is probably reinforcing to the pupil. Skinner brings out the fact that the child may progress at his own rate. Even if the child is away from school, he may return to the machine and pick up where he left off, so that absences need not interfere with learning. He states that material for the teaching machine should be carefully graded so that the child will make almost no mistakes.

Skinner suggests a device similar to his arithmetic machine with sliders which carry letters of the alphabet for use in teaching spelling. Skinner foresaw critical attack from those who would decry educating the child by machinery. He points out that mechanical devices are designed to eliminate the more tiresome labors of the teacher, but that machines will not necessarily shorten the time during which she remains in contact with the pupil. Skinner feels that schools can well afford mechanical devices and sees no reason why the classroom should not be at least as automated as the family kitchen.

Skinner, B. F. *Report No. 1 on the Development of Methods of Preparing Materials for Teaching Machines.* Subcontract No. HumRRO-1-001, George Washington University, Washington, D. C., April 1, 1957; cited by Darby, 1959.

"The problems of determining the content of courses to be taught and the transforming of these statements of 'what to teach' into a form suitable for use in a machine program are discussed. 'In constructing a program, the principal concern is the elicitation of the correct response with a minimal chance of error'." (from Darby)

Skinner, B. F. *Report No. 2 on the Development of Methods of Preparing Materials for Teaching Machines.* Subcontract No. HumRRO-1-001, George Washington University, Washington, D. C., April 1, 1957(a); cited by Darby, 1959.

"This report contains a discussion of the generation and programming, or ordering, of statements to be included in teaching material. Principles of programming should be applicable to subject matter—exact, communicable, and effective." (from Darby)

Skinner, B. F. *Final Report to Human Resources Research Office.* Subcontract No. HumRRO-1-001, George Washington University, Washington, D. C., October 1, 1957(b); cited by Darby, 1959.

"A detailed description of Skinner's teaching machine and its use is given. The importance of the program used in the machine is stressed and some of the problems of programming are discussed. Some techniques to bring the desired behavior under the control of the designated stimuli are "leading," "vanishing," and "prompting." The author discusses some of the reactions to teaching machines and argues for the efficiency of machine teaching." (from Darby)

Skinner, B. F. *The Use of Teaching Machines in College Instruction.* Final Report to The Fund for the Advancement of Education, August 15, 1958; cited by Darby, 1959.*

"This is the final report of work done under two annual grants by The Fund for the Advancement of Education in

investigating the place of teaching machines in the utilization of college teaching resources. It consists of four parts:

"Part I is a general discussion of machine instruction. It is written as a separate paper and is published in *Science*, 1958.

"Part II is a detailed statement of the most useful features of teaching machines in the present state of the art.

"Part III is an analysis of the problems of programming knowledge for machine instruction.

"Part IV is a detailed report of our experience in teaching part of a course on Human Behavior at Harvard and Radcliffe in the Spring term, 1958." (from Darby)

Skinner, B. F. "Teaching Machines." *Science*, Vol. 128, No. 3330, October 24, 1958.*

This is Skinner's major article on teaching machines. Originally it was part of a report to The Fund for the Advancement of Education.

Skinner notes the present need to improve classroom instruction and an increased use of audiovisual aids. He feels, however, that there is a real danger in the use of equipment which is designed only to *present* material. The student is in danger of becoming more and more a mere passive receiver of instruction. Skinner cites Pressey as an early developer of another type of automated equipment, namely, the teaching machine. Pressey, he believes, was working against an inadequate background of psychological theory, for the learning theory of the day was dominated by the memory drum and similar devices. Rate of learning was observed but little was done to change it.

Skinner explains the failure of educators to make more adequate use of mechanical devices, saying that Pressey's earlier machines succumbed in part to cultural inertia. He does give Pressey credit for being one of the first to emphasize the importance of immediate feedback, but states: "The learning process is now much better understood." (p.970) He sees a surprising degree of control achieved by arranging appropriate "contingencies of reinforcement."

Skinner would have the student recall the response rather than select the response from among a set of alternatives, as is done in a multiple-choice device. The reason for this is that he wants the student to be able to recall the response rather than just recognizing it. Plausible wrong responses are out of place in the delicate process of "shaping" behavior, he believes, because wrong responses strengthen unwanted forms. Skinner's second minimal requirement for a teaching machine is that it requires the student to pass through a carefully designed sequence of steps.

He mentions the Arithmetic Slider machine (also mentioned in this bibliography under Meyer). In this machine a student constructs answers to arithmetic problems by moving sliders. If the problem is answered correctly the machine can proceed to the next problem. It has been used mostly in teaching arithmetic in the lower grades.

Skinner's disc machine was designed for use with more advanced students from junior high school through college. Material is presented on the disc, one item at a time, through a viewing slot. The student responds on a separate paper tape. After responding, the stu-

dent activates a lever which causes the answer to be shown in the viewing frame and moves his written answer on the paper tape under a sheet of glass. The student compares his answer with the machine's answer and scores himself right or wrong. If the item is right, it is not presented again; if it is wrong, it is repeated on the next round. Each 12-inch disc contains 30 frames. The student is asked to repeat each incorrect frame until he achieves a perfect score.

Skinner feels that the machine is surprisingly like a private tutor in that it brings the student into direct interaction with the material and permits him to proceed at his own rate. The machine, like a tutor, "insists" that a given point be thoroughly understood, either frame by frame, or set by set, before the student moves on. Skinner notes that lectures, textbooks and other mechanized equivalents do not do this.

He describes several methods of programming, one of which he calls "vanishing." Under this principle, for example, an entire word may be given in a spelling lesson. Gradually parts of the word are removed, the student being required to respond by filling in the blanks. At the end of a sequence of steps, an entire word is "vanished" and the student is asked to respond by filling in the entire word. In the teaching of arithmetic, Skinner has the student learn the operations of addition, subtraction, muliplication and division thoroughly before they proceed up the number range. For example, a child would know how to do all of those operations for numbers below "the concept of five" before he would proceed to "the concept of six." Skinner does not favor rote memorization.

Skinner favors the use of charts and diagrams, graphs and pictures in connection with his machine. He even suggests the possibility of using auditory material by means of an indexing phonograph. For example, in learning to take dictation in a foreign language, a short passage is played on the indexing phonograph. The student responds by writing down the passage. Then he is shown the passage on a teaching machine. The article contains other provocative examples of programmed material.

Skinner states that empirical tryouts with students is the final authority for programming material. All programming material should be tried out on actual students, and feedback from this tryout given to the programmer. He states that "hard" material may be just another name for poorly programmed material. Reference is made to the work of Gilbert, Porter, Sapon, Ferster and and Holland.

Skinner considers self-scoring devices and workbooks unacceptable because they do not present the material one frame at a time, and because some sort of mechanical presentation is necessary to make successive frames independent of each other. He sees no possibility that machines could replace teachers. Rather, machines can make teachers more productive.

He gives an interesting concept about grading. Henceforth grades will mean completion. Faster students will have many completions of subjects but the traditional A, B, and C will not stand. The only grades given will be for mastery of all the subject material in a course.

He foresees the use of machines in industry, special education and special

schools. One of the outstanding characteristics of the machine as used in special education (especially with retarded children) is its "infinite patience."

Skinner, B. F. "The Programming of Verbal Knowledge." In *Automatic Teaching: The State of the Art*, edited by Eugene Galanter. New York: John Wiley & Sons, 1959.

Skinner believes that the shaping of a a written response through "successive approximation" is ineffiicient. Successive approximation here refers to the manner in which he teaches pigeons to play ping-pong. That is, a subject is rewarded each time he closely approaches the goal; the subject is then rewarded the next time only if he gets closer to the goal, and so on in ascending approximation. Skinner does not consider this effective in shaping verbal responses. He prefers the technique known as "vanishing." In vanishing, the total word is first presented; then one small part is removed for the succeeding item. On the second item, two small parts are removed, and so on, until the whole word is finally removed, or "vanished."

In addition to vanishing, Skinner observes that sometimes a student may combine known elements for a response. Moreover, the use of a term or fact in another syntactical (sentence order) arrangement makes a good type of item. An important goal is the enrichment of "understanding." Skinner here defines understanding as the use of a fact under several different conditions, which is a process of recombining. Hence, just answering a question correctly is not necessarily the goal.

The method of juxtaposition is used in combining a nonverbal stimulus, such as a symbol with a word. A verbal response may be brought under verbal control by the method of "equating," an example of which would be "X" means Y," or use of the word "or," or use of substitution. He believes that much of learning a new language is of this nature.

Skinner is interested in the following types of problems in the development of teaching machines: (1) What are the optimal physical dimensions of frame set programs, etc.? This would include whether or not to use visual or auditory material, and under what physical conditions. (2) How are programs related to the overall curricula? This would include some knowledge of the student's present development, as well as the problem of individual differences. (3) How are we to define and analyze a subject matter and a definite and plausible sequence of steps leading from complete ignorance to complete competence? Sometimes this can be solved by simply programming an ordinary textbook.

Skinner lists a number of other problems which need investigation: the optimal level of difficulty to be used, the optimal frequency of recurrence of similar material for review, the optimal frequency of exercising, the optimal schedules for feeding review material, the possible use of relatively unrelated material to break up a too powerful control by a given universe of discourse, and the optimal use of schematic or formal supporting material.

Skinner refers to his book, *Verbal Behavior*. New York: Appleton Century Crofts, 1957.

Smith, Donald. "Speculations: Characteristics of Successful Programs and Programmers." In *Automatic Teaching: The*

State of the Art, edited by Eugene Galanter. New York: John Wiley & Sons, 1959.

Among numerous comments and examples of programming, Smith outlines the following steps in programming: (1) define the behavior desired, (2) determine the steps to achieve that goal, (3) introduce concepts, (4) induce a web of learning (this refers to the making of many associations in integrating new concepts, similar to what Skinner means by "understanding"), (5) summation (this refers to integrating only items as a whole), (6) review. Review should be done both immediately (every five or 10 frames) and delayed (every 20 to 40 frames).

Smith also suggested that the steps be small, that one concept be taught at a time, and that reinforcements be frequent. While bright students could skip steps, dull students need more items. He further suggested that more items might not hurt the bright students who can work them very rapidly. He noted that dull students develop "retention and attention" problems after failing several steps.

Smith is one of the few writers in the field of teaching machines who is concerned about the qualifications of a good programmer: "One of the most striking similarities among the successful programmers with whom I have worked is an inverted style of thinking." He believes that a programmer tends to be analytical, deductive, methodical, perfectionistic—in short, the classical or Jungian introvert. The inverted thinker is contrasted with the extrovert who skims through the conceptual surface of life, tends to think elliptically, synthetically, indefinitely.

A good programmer tends to continue the task long after a normal or especially extroverted person reaches the point of satisfaction. In fact, recent studies of introversion and extroversion revealed that these personality types may be related to neurophysiological phenomena; hence, style of thinking may be largely constitutional. In fact, Smith states that the selection of personnel for writing programs may be facilitated by using a measure of introversion-extroversion such as the SA-S scale. (See also, Smith, D.E.P.; Wood, R.L.; and Carrigan, P.M. *The SA-S Senior and Junior Scales*. Bureau of Psychological Service, University of Michigan, 1959).

Spence, Kenneth. "The Relation of Learning Theory to the Technology of Education." *Harvard Educational Review*, Vol. 29, No. 2, Spring 1959.

Spence declares that the time is ripe for a combined research effort between psychologists and educational psychologists, particularly as far as teaching machines are concerned. He believes that programming should properly be undertaken jointly by a subject-matter specialist and a psychologist. He states that teaching machines use immediate reinforcement which is approved by all theorists. The teacher's new role is to build up the student's interest and goals which would serve as secondary reinforcers and incentive motivators. In this respect school rooms are deficient today; teaching machines may make for better reinforcement.

Stephens, Avery L. "Certain Special Factors Involved in the Law of Effect." *Abstracts of Doctoral Dissertations*, No. 64, Ohio State University, 1953.*

This investigation attempted to discover the value of two devices, a punchboard and a "drum tutor," (a simple

multiple-choice type of device). Stephens also attempted to investigate the general nature of the learning process involved.

The punchboard has been previously described in Pressey's 1950 article. The Drum Tutor is described as a small box measuring 3½x4½x5 inches. On the front of this device are four keys in a small window showing the number of the test questions to be answered and an error window showing cumulative count of errors. Questions are printed on a separate mimeographed sheet.

More than 1500 students in various psychology classes at Ohio State were subjects in this investigation. All practice tests consisted of 30 multiple-choice, or alternative questions.

The first part of the investigation assessed the meaningfulness of the material to be learned. Three practice tests were taken on punchboards. The investigator referred to this as a "retained" situation because the questions were retained before the learner until he found the right answer. A definite increase in learning was found with each trial in all three types of material (nonsense, Russian, and hard English vocabulary). As a type of control, a test-as-test situation was used in which the subject was allowed one response to each item without obtaining any information as to rightness or wrongness. The three trials showed no increase as would be expected.

Punchboards were also used in a vanishing situation (vanishing here refers to the Thorndike use rather than to the Skinner use). In this situation each subject makes one response to each item and gains information as to rightness or wrongness, but he does not respond again to that item until the next time he goes through a practice test. Some learning occurred under the vanishing situation, but the retained situation was found to be the most effective. As to meaningfulness, both Russian and English showed higher learning than nonsense syllables. Stephens found that Thorndike's theory is wrong in that knowledge of wrongness and knowledge of rightness appeared to be equally effective in causing learning.

Stephens did have some interesting comments on multiple-choice programming under what he called "special test arrangements." He investigated the possibility of "inside alternatives," that is, each wrong alternative for each item appeared as a right choice for another item. He compared this with the usual type of alternatives test in which none of the alternatives, whether right or wrong, appeared more than once. He found no difference on an end test, after three times through a practice test, for either nonsense syllables or Russian. However, when he used special grouping of inside alternatives (each right alternative appeared as a wrong alternative for the three items immediately following), he did find it conducive to learning.

Stephens next compared the Drum Tutor with the punchboard, and found that the cumulative number of errors presented by the punchboard was not helpful. However, he did find repeated runs through a test to be valuable. Apparently students could run through a test using a Drum Tutor more rapidly than they could using the punchboard. He also found that three times through the same practice test gave as good end results as three times through a practice test in which the order of the items and patterns of alternatives were changed.

He concluded that the convenience of repeating a test on the Drum Tutor was a real advantage.

When the Drum Tutor was used in a course in educational psychology, students using it scored better than control students who used no special devices. Stephens states: "In general the Drum Tutor section did as well on the examinations as several groups using the punchboard for only one trial with the same practice test and did better on items repeated from practice tests." He reports that students favored the Drum Tutor.

Twyford, Loran C. "Profile Techniques for Program Analysis." *Audiovisual Communication Review*, Vol. 2, No. 4, 243-62, Fall 1954.

Twyford describes a type of "group feedback machine" which originally was designed for the analysis of motion pictures, lectures, radio and other types of group presentations. Experimentation was done under contract for the Special Devices Center, ONR. The type of device used is known as a "response analyzer." Each subject holds a dial in his hand. The dial has a small knob connected to a resistance valve. The subject indicates when he thinks he is learning by turning the dial from low to high. All individual resistance valves are wired together on a console which the teacher may observe. A graph may be drawn either of each individual student or of the class collectively.

Twyford found that the graphs showed a general agreement between "opinion of when learning" and scores on test items (a Pearson *r* of .64 was computed). At least three response analyzers are commercially available, one known as the Think-O-Meter, another as the G. E. Response-Analyzer. While these devices are not exactly teaching machines, they do have some similar characteristics, such as feedback.

Twyford, L. C.; O'Hara, J. G.; and Goldman, A. *Green Light Rater.* Technical Report NAVTRADEVCEN 20-0S-3-1. U. S. Naval Training Devices Center, Port Washington, New York, December 23, 1958. 5 p.

This report is abstracted by Twyford in the Summer of 1959 issue of *Audiovisual Communication Review* (page 239) as follows:

Purpose: The purpose of this research and development project was to design and evaluate a teach-test, or self-rating device which would incorporate good psycho-educational principles and which would permit the user to prepare and change the questions.

Procedure: A device was designed to provide teaching and practice to supplement more formal classroom instruction. It was designed to be inexpensive, adaptable to the physical environment of the trainee, and require minimal maintenance. Psychological factors involved in its design included (a) incentive motivation, (b) knowledge of results—immediate, specific, and differential, (c) repetition, (d) contiguity, (e) distribution of trials, (f) incidental learning, and (g) lack of stress. The apparatus displays 42 cards containing multiple-choice questions. One of four buttons beneath each card glows green if correctly pressed; the others glow red to indicate errors. Field evaluators answered a number of questions regarding the degree of use, maintenance problems, reactions of trainees, et cetera.

Results: This rater was found to have the advantage of similar teach-test devices. Production costs were estimated to be below those of similar devices; it was easy to operate and maintain. With two modifications it was recommended for production.

Weimer, P. K. "Proposed 'Automatic' Teaching Device." *Institute of Radio Engineers, Transactions on Education* E-1:51-53, June 1, 1958. (Reviewed in *Engineering Index*, 1958.)*

" 'Automatic' teaching device is one which incorporates both presentation of information and testing of student in controlled feedback relationship; paper presents case for 'automatic' teaching devices along with some proposals for

construction of such machines" *(Engineering Index,* 1958).

Zeaman, David. "Skinner's Theory of Teaching Machines." In *Automatic Teaching: The State of the Art,* edited by Eugene Galanter. New York: John Wiley & Sons, 1959.

Skinner's theory is that the appropriate experimental paradigm for programming teaching machines is its "free operant" conditioning. Other experimenters (those using the Memory Drum, for example) assert this to be inappropriate. Zeaman holds that a more appropriate theory would state there are three basic experimental paradigms: the free operant, the controlled operant, and classical conditioning. Of these three, the free operant may be the least pertinent. He classifies Skinner's write-in model teaching machine as a memory drum.

Zeaman defines the controlled operant as having the following features: (1) The trial begins with the presentation of the stimulus. (2) One or more incorrect responses are allowed and recorded. (3) Only one correct response per trial is allowed because the correct response terminates the stimulus. (4) This brings on the second stimulus, S_2, which is a reinforcing stimulus. (5) The second stimulus does not elicit response. (6) The inter-trial interval duration between the reward S_2, and the next stimulus S_1, is usually under the control of the experimenter (as opposed to the first stimulus S_1, reward S_2, interval which is under the control of the subject). (7) Acquisition is measured by latency or the probability of a correct response. Apparatuses which illustrate the controlled operant include the runway, the jumping stand, and the simple T maze.

The free operant is similar to the above, except that stimulus S_1, is of prolonged duration, allowing for multiple responses (and consequent rewards) and permitting a rate measure to be taken.

In the classical case, the important distinction is the nature of reward (S_2). It is not contingent upon correct responses; instead, it elicits correct responses. Zeaman feels that Skinner's arithmetic machine incorporates all of the features of the controlled operant but not all those of the free operant. He thinks that the write-in model has elements of classical conditioning but no elements of free operants that do not overlap with those of controlled operant or classical conditioning.

He concludes that there is a large literature of controlled operant and classical conditioning that is relevant for construction and programming of teaching machines, and that Skinner's theory leads to a neglect of this potentially valuable source of pertinent data.

IV. Bibliography of Commercially Developed Teaching Machines

Dyna Slide Company, 600 South Michigan Avenue, Chicago 5, Illinois.

Program Scanner. The Program Scanner will vertically scan a program, allowing written-in answers at each step while keeping all other parts of the program concealed. As the scanning window is moved to the next question, the correct answer appears in the small window to the right. The answered question remains in view for comparison. Upon completion of the last step on a program page, the scanning window is returned to the top position. At this time, the completed program page can be removed revealing the first step on the next program page.

Electric Boat Company, Division of General Dynamics Corporation, Groton, Connecticut.

The All Electric Auto-Score. This device is a multiple-choice teaching machine designed to fit on top of the student's desk. Approximately the size of a portable typewriter, it makes use of a plastic sheet, 8½ x 11, containing 10 multiple-choice questions, each a five-choice item. The device works by means of printed circuits which appear on the back of the plastic sheet and are not visible to the student. The student responds to each question by touching the right answer with an electric stylus. The device gives immediate knowledge of results. Questions are presented one at a time, and the device does not proceed until the present question has been answered correctly. Correct and incorrect choices are registered on dials (a lapse time indicator being available). An optional feature mentioned in the draft is a printed tape readout which automatically prints score and time.

The same device also comes in another model that can handle 20 questions. The student responds by pressing keys. It is not known whether Electric Boat Company is proceeding with the development of this device.

Foringer and Company, Inc., Rockville, Maryland.

The Foringer Teaching Machine. Foringer developed two hand-made shop models of a simple write-in type of teaching machine similar to the device which Porter developed at Harvard University. They were designed so that programmed material could be prepared on a mimeograph or ditto machine on 8½ x 14 fan-folded paper chains. Responses are written on a separate answer tape which is also fan-folded and contained within the machine. A lever attached to a continuously variable clutch permits the material to advance so that only one item at a time can be seen and responded to. Correct answers are pre-

sented when the problem is advanced so that they can be compared with the student's written answer, thus affording knowledge of results. The Foringer machine was designed to be low priced, the first experimental models costing under $100.

General Atronics, Bala Cynwyd, Pennsylvania.

Atronics Tutor. This is a simple multiple-choice device which programs material printed in a special booklet. The booklet is placed in the machine and the student responds by pushing one of four buttons. If he has selected the right button, the next page falls into view; if not, the same question remains. The machine "reads" the answers on the cards by means of special notches cut in the edge of the pages. Eugene Galanter of the University of Pennsylvania assisted in the development of this machine.

Harcourt Brace and Company, New York City.

Programmed Text. Harcourt Brace has experimental copies of a special type of programmed textbook which contains English grammar subject matter. The questions are presented on a page with answers given in a column to the right. The student reads the question while he covers the answer with a card. After responding, he removes the card and checks his answer. Stanley Rice, the Harcourt Brace representative, states that the company is interested in developing programmed material for schools and hopes to have this grammar book on the market shortly.

Instrument Research Company, Garden Grove, California.

Multiple-Choice Card Teaching Machine. This device is a simple multiple-choice teaching machine. Items are placed on 3 x 5 cards and the student responds by pushing a button. If the choice is wrong nothing happens but if the choice is correct a green light is shown and the student may proceed to the next item. Every card not answered correctly on the first attempt is segregated.

Punchboard. This company has also manufactured some aluminum experimental sets of Pressey's punchboard.

Management Research Associates, 317 Sauk Trail, Park Forrest, Illinois. (Nelson, C. W.)

The Multiple-Purpose Self Trainer. This device, commonly called a "pluck-card," is designed to be used with multiple-choice questions. The shorter version of the card contains 10 answering rows. The student reads a multiple-choice question from another sheet of paper and responds on the pluck-card by pulling off a tab overlay on which is marked "a, b, c, d, or e." When the tab is pulled off it reveals a letter. The letters revealed are "A, K, Q, J, and T" (these stand for Ace, King, Queen, Jack and, Ten, the idea being that Ace is the best possible choice, King the next best choice, and so on). This card was originally designed for use in management training situations.

Nelson also has a larger version of the pluck-card which can handle 24 items. Beneath each of the tabs is an O or an X, the X being the correct answer, the O indicating a wrong choice. There may be from one to four X's which could indicate a correct answer; this varies with each line. Using a right-minus-wrong formula, the long form of 24 items will yield a score ranging from minus 60 to plus 60, or a total range of 120 points.

A manual accompanying the self-trainer refers to Angell's experiment with chemistry students and mentions many of the values of this punchboard type of training device. Nelson seems to have contributed a fairly original type of knowledge of results, namely, the ranking of answers in the "Ace, King, Queen" series and his several correct answers in the X-O system. He has further suggested a possibility of weighting the Ace, King, Queen system so that an Ace would receive one point, a King two points, a Queen three points, and so on, the lowest score being the best.

The manual states that the student is to keep trying on each item until the Ace turns up. An explanation is also given of how to use the self-trainer with true-false tests and with three-, four-, and five-choice multiple-choice questions. Suggestions on item writing are made as follows: (1) do not make a negative statement, (2) never reveal the right answer by making it longer, and (3) put the alternative responses at the end of the sentence. In personal correspondence Nelson stated that the short (10-item) self-trainer is sold for 10 cents and the longer form (24-item) for 15 cents, with some reduction in price for research purposes.

Rheem Manufacturing Company (now Rheem Califone Corporation). Electronics Division, South Gate, California.

DIDAK 101 Pre-Verbal Machine. This machine was originally designed by Skinner and his followers (one of whom was possibly Wells Hively) for work on discrimination learning with preschool children. The question part of the item is presented behind a large picture window made of lucite. The student touches the window to indicate that he is going to respond to the item shown. He then touches one of three other smaller windows beneath which is a picture or design similar to the one presented in the major window. Each of the windows has an electric switch. When the correct association is made, the machine automatically presents the next problem.

DIDAK 601 Multiple-Choice Machine. This is another multiple-choice machine designed by Skinner which presents the question in a large window, beneath which are three windows with three corresponding buttons. The student responds to the question by pressing the button opposite what he thinks is the correct answer window. When the right answer is presented, the machine automatically proceeds to the next item.

DIDAK 501 Simple Recall Machine. This is a simple write-in type of machine which Rheem sees as the successor to Skinner's disc machine. Questions are presented in one window and the answer is to be written in another. The student may then advance the program and see the answer which he can check against his written answer. He is asked to score his answer right or wrong. The research model of this machine provides for a marking of each error on the back of the sheet so that an automatic count is maintained for each item. This is useful in developing programs.

DIDAK 1001 Psychomotor Skill Trainer. This device is used to train key punch operators and was previously described as the SAKI with original work done by Gordon Pask. The first model utilized an English key punch keyboard. A sample data card shows one illuminated number. The student responds by punching a number on the

keyboard which illuminates the next number. Gradually the speed and complexity of number sequencing is increased. In case of an error the machine gives an inordinately long pause, so that immediate knowledge of results is available by having the machine proceed at a normal pace. The electronic center of the machine contains a self-organizing computer. This device can be modified to use IBM key punch, typewriters, and adding machines for training.

Science Research Associates, 57 West Grand Avenue, Chicago, Illinois.

Angell-Troyer Punchboard. This is a punchboard which provides feedback to multiple-choice responses. An 8½ x 11 answer sheet is held in a plastic holder. The student responds by punching a hole in the paper. Knowledge of results is provided by the appearance of a red dot beneath the punched hole if the answer chosen is correct. The punchboard was put out several years ago, and was not for sale in 1959.

Teaching Machines Inc., Box 28, Albuquerque, New Mexico.

Programmed Textbooks. This company is designing and printing programmed textbooks written by Jim Evans with the assistance of Lloyd Homme and Robert Glaser. They have completed a textbook for a college statistics course and are planning programmed texts in other subjects.

Omnideck. The Omnideck is simply a set of data-processing cards which contain exactly the same instruction material as a programmed text. One side of the card contains the question and the second side the answer. Omnideck cards can be printed on IBM, Rand, or McBee cards for sorting. The company states that Omnideck material is especially suitable for experimental work when branching reinforcement or rate of response is to be varied.

Wycoff Film Tutor. This machine upon presenting a step will not advance until the student has correctly composed an alphabetical or numerical answer. The machine shows the correct letter or number and will continue to spell out the answer as rapidly as the student answers correctly. When the right answer has been automatically displayed a separate lever advances the machine to the next step.

This device can hold in excess of 1000 frames, is portable, and is designed to fit on a student's desk. It is 10 inches wide, 6 inches high, and 20 inches long. The top raises to a 45° position and is propped by a 7x9 rear projection screen which folds up in the rear half of the case. A concealed filmstrip projector displays a problem on the screen. The student composes his answer using a set of five keys at the front of the box. The 32 possible combinations of the five keys allow either for all the letters of the alphabet, or the 10 digits. The manufacturers believe that the greatly reduced cost of the electronics for this method of composition, as compared to typewriter keyboard, offsets the hour or two required to learn the alphabet code. For teaching children the keys can be used for multiple-choice responses.

Wycoff-Cornell Language-Tutor. A second model is available—the Wycoff-Cornell Language-Tutor. It is identical to the Wycoff machine but in addition incorporates a transistorized audio circuit. A taped audio question or response of any desired length is presented concurrently with the visual frames.

United States Navy, Special Devices Center, Port Washington, New York.

Tester-Rater, Self-Tutoring Punchboard, Device 20-E-2-e. This is a Navy version of Pressey's punchboard, described in some detail in Pressey's 1950 article. The Navy version handles 40 four-choice items per side, making a total of 80 items for the punchboard. Inserted in the center of the device are two scoring templates which yield a total of eight variations in a punchboard key per side. Figuring that the sides can be switched, a total of 16 variations is possidle. This device is also listed in the *Training Device Guide,* formerly *Special Devices Guide* of the U. S. Naval Training Center, Port Washington, New York, revised November 1957 (NAVEXOS P-530-2).

A visit to the Special Devices Center in December 1958 yielded information that some 1200 of these devices had been sent to the fleet, the manufacturer having been unable to fulfill the Navy's original request for 15,000.

Van Valkenburgh, Nooger and Neville, Inc., 15 Maiden Lane, New York 38. (Copyright Holder)

Trouble-Shooting Trainer-Tester. The Trainer-Tester is a type of paper teaching machine which is used to simulate actual equipment for trouble shooting and similar problems. In order to use the Trainer-Tester, four sheets of paper are required. The first is the "trainer-tester step-by-step instructions." Two others are a "trainer-tester schematic diagram" and a "trainer-tester wiring diagram." The student performs the actual work on a fourth worksheet which is called the "trouble-shooting trainer-tester for the (in this case) super-heterodyne receiver." This sheet contains areas in which the subject may simulate electronics checks, such as from circuit to ground. The simulation is done by erasing a silver overlay which exposes knowledge of what would happen in this particular problem if the check were made at this numbered point. The numbered point refers to a spot on the wiring or schematic diagram.

One characteristic of this device is that several steps are made with feedback before the final solution to the problem is attempted. The final solution in some cases may be the replacement of a faulty part. When the student simulates replacing a faulty part, he is informed of whether or not the problem is solved. Efficient problem solvers make fewer checks, and hence fewer erasures on the silver overlay.

Western Design, Division of U. S. Industries, Inc., Santa Barbara, California.

The Western Design Tutor. This device is described as an automatic random-access recording microfilm and motion picture projector. The device stands about four feet tall, is two feet wide and three feet deep. It contains 1000 motion picture frames which can be presented in any order by pushing buttons in front of the control panel. The teaching machine program presented in the display machine is simply that of Crowder's Scrambled Book. However, the device could be made to show short sections of motion picture film. It is anticipated that when perfected, the machine will show up to 10,000 individual frames, any one of which can be selected at random. One feature of the machine is a recording unit which makes it possible to record on a continuous tape the time of each operation as well as the number of the page selected.

POSTSCRIPT

IT WAS THE AUTHORS' INTENTION to include all references to teaching machines which fit our definitions, either as published references, technical reports, or manufacturers' announcements. We apologize for any omission and earnestly hope that the authors or manufacturers will communicate with us, as the editor of this journal has discussed the possibility of a future updating of this bibliography.

The teaching machine field is very active right now and seems to be "growing like Topsy." It is difficult to keep abreast of all the developments. Bits of information come to us from many informal sources. Readers might be interested in the following paragraph in a letter from John Barlow at Earlham College: "Charles Ferster (Institute for Psychiatric Research, Indiana University Medical Center, Indianapolis) has developed a semi-automatic tutor and method for duplicating programs. Isabelle Hoose (Kent State University, Kent, Ohio) has a portable Porter-type machine which a local company is willing to manufacture."

We also hear that John Blyth of Hamilton Research Associates (Route 5a, New Hartford, New York) has programmed a course in Symbolic Logic; Hollins College near Roanoke, Virginia, has received a $68,200 grant from the Carnegie Corporation for research in this field; Irving Saltzman at Indiana University is working on a program in Russian; and Davis Instruments (12137 Cantura Street, Studio City, California) has a "projector programmer" that selects 35mm slides for viewing by pre-programming which the manufacturer calls a "basic unit" of a teaching machine.

If the curve drawn in Figure I is any indication of continuing growth, everyone interested in teaching machines will have much to witness in the next few years.—E.B.F.

ANNOUNCEMENT

The National Education Association and its Department of Audio-Visual Instruction are publishing (in May 1960) a comprehensive and authoritative reference work on concepts and techniques of "programmed" individual instruction and automated teaching devices.

Edited by A. A. Lumsdaine and Robert Glaser, this volume will bring together for the first time the basic papers published by leaders in the development and programming of teaching machines during the last four decades.

This volume, TEACHING MACHINES AND PROGRAMMED LEARNING: A SOURCE BOOK, *will contain approximately 400 pages and sell at $4.50 per copy. Advance orders may be sent to the Department of Audio-Visual Instruction, National Education Association 1201 16th Street, N.W., Washington 6, D. C.*